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Steam Engine Research.

Soon after the constitution of the Steam Engine Research Committee of the Institution of Mechanical Engineers, at the instance of the late Mr. Bryan Donkin, to investigate the subject of initial condensation in steam engine cylinders, a French firm undertook to provide an experimental engine for the purposes of the inquiry. The special feature of this machine was to have been the provision of two supply valves, one to admit steam during lead the other to act as the admission valve. By supplying the first and second valves from separate boilers it was hoped that the steam required to replace initial condensation might be measured separately. Ultimately, this form of experiment had to be abandoned as the makers were unable to carry out their undertaking, and the committee then accepted the offer made by King's College, London, to place an experimental engine at their disposal. Several years have elapsed since the committee was constituted, but at last we have some record of their work in the report by Professor Capper, incorporating the results of the experiments conducted at King's College.

The engine used was specially made by Messrs. Marshall, Sons, & Co., of Gainsborough, for the purpose of the trials, and is of the horizontal compound type. Each cylinder is separately jacketed on the barrel and the ends, and separate supply and drain pipes are provided for each jacket. Although constructed so as to permit of numerous adjustments to provide adequate facilities for investigation, the engine, in any one of its varied adjustments, practically represents an ordinary commercial engine.

In accordance with the decision of the committee, the low pressure cylinder was not used, the engine being run as a single-cylinder high-pressure engine, exhausting into a surface condenser with the vacuum reduced to 2 in. to 3 in. of mercury, thus maintaining back pressure in the cylinder at atmospheric pressure. Two series of trials were made, the first with the cylinder jacketed, and the second series practically a repetition of the first, but without use of the jackets. It was further determined by the committee that the variables should be temperature and speed all other conditions being kept constant. The temperatures selected were 245 degrees, 280 degrees, 315 degrees, and 350 degrees Fahr., corresponding with 27 lb., 49 lb., 81 lb., and 135 lb. per sq. in., and the speeds 50, 100, 150, and 250 revolutions per minute. Numerous preliminary trials were made with the object of settling the best cut-off, and methods of adjusting and working the measuring apparatus, and, as the result of these, it was found necessary to work the boiler at somewhat higher pressures than

those actually required, and to regulate temperature in the steam chest by slightly throttling the steam at the stop valve of the engine. More than one hundred trials were carried out, and of these thirty-eight have been selected as most closely satisfying the conditions laid down. Calculated results and detailed observations are given in tables at the end of the report.

It may here be mentioned that, owing to the demands upon the staff at King's College, it was impossible to continue the investigation from day to day, and it was often the case that intervals of a week or more elapsed between consecutive trials. This accounts for the somewhat tardy appearance of the report, which has been expected for a long time by all interested in the improvement of steam engine design.

In working out the results of the tests a mean indicator card was constructed for the whole of the diagrams taken on each trial, and upon this all the calculations were based. From the condensed water, measured at the exhaust, a saturation curve was plotted on each mean diagram representing the volume of the mean steam passing into the exhaust per stroke. If all the steam represented by the water of condensation had actually passed through the cylinder the difference between the expansion and saturation curves would represent condensation in the cylinder. But it must be recognized that a certain proportion of steam leaking through the slide valve and past the piston will not be shown in the expansion curve of the diagram, and that other leakages past the same points will also affect the diagram. Such leakages are of greater extent than is commonly supposed, and an excellent feature of Professor Capper's work is to be found in the measures taken for the determination and analysis of the various leakages taking place. The analyses so made demonstrate the point that without due allowance for leakages no correct estimate can be made of the relative weight of steam and water present in the cylinder. In calculating the thermal units per horse-power consumed by the engine no account was taken of losses outside the steam chest, but allowance was made for the slight superheating due to throttling the steam at the feed valve.

Although the Rankine engine was chosen as the standard of comparison, the tabulated results contain data for the convenience of those desiring to compare the experimental engine with the Carnot engine. Another excellent feature of the report is the presentation of entropy diagrams for each temperature series and each speed series. These, being superimposed one upon the other, facilitate direct comparison of the thermal units required at constant speed, as well as at each temperature and at each speed.

We have already mentioned the importance of considering leakage through the slide valve. Under ordinary working conditions it is probable that during admission the flow of steam into the cylinder has the effect of minimising leakage from the steam port through the valve into the exhaust, but during expansion and compression the leakage is governed by the difference existing between the expansion or compression pressure on one hand and the exhaust pressure on the other. In a paper read some time ago before the Institution of Civil Engineers, Professor Callendar and Dr. Nicholson suggested that leakage through the valve probably takes place in the form of moisture condensed on the valve face and then re-evaporated. The correctness of this conclusion is confirmed by the results of Professor Capper's leakage experiments, which were made with tightly closed ports, the engine being driven at the different trial speeds by external power, while steam of the different selected pressures was admitted to the steam chest. In order to imitate working conditions as closely as possible, the cylinder walls, slide face, and surrounding metal were kept warm by the employment of the cylinder barrel and jackets. The following table is condensed from Tables 1 and 2 given in

the report relative to leakage through the slide valve.

From the results given in the foregoing table, which applies both to the jacketed and non-jacketed trials, it will be seen (1) that with the exception of the 50-revolution test a distinct reduction of leakage follows adequate lubrication of the sliding surfaces; (2) that leakage increases with the difference of pressure in the steam chest and exhaust respectively, and (3) that leakage diminishes with the increase of speed.

As measurements taken with the valve in mid position showed considerably less leakage than when the engine was running, a series of experiments was made with the valve in nine different positions in the hope of determining the influence of overlap upon leakage. From the data so obtained it is clear that variations occur approximately in the inverse ratio to the overlap. It is interesting to observe that the conclusions of Professor Capper are substantially in agreement with those of Professor Callendar and Dr. Nicholson.

Leakage past the piston was found on measurement to be comparative unimportant, the maximum amount not exceeding 2 per cent. of the steam supplied to the engine. The escape in this way was found to be independent of the number of revolutions per minute and proportionate to the admission pressure and area of indicator diagram on the working side of the piston.

Comparison of the data quoted in the foregoing table, with the total steam consumption makes clear the fact that under the stated conditions of working the leakage ranged from 4 per cent. to 20 per cent. of the total steam used. This being the general result in an engine designed and fitted with unusual care, the percentage in a commercial engine must be considerably more, and it is perfectly clear that the question is one demanding the serious attention of engine builders and users alike.

In comparing the jacketed with the non-jacketed trials we observe that the indicator diagram presents very similar general features. In every case the leakage correction materially affects the estimated initial condensation, to investigate which is the main purpose of the committee.

In the jacketed trials, condensation during admission ranged from 0·4 lb. up to 6 lb. per 1,000 strokes, and in the non-jacketed trials initial condensation varied from 1·86 lb. to 18 lb. per 1,000 strokes. Generally, the total condensation up to the point of cut-off increased with the increase of pressure and temperature of admission, and as the cut-off was constant, condensation increased with the difference between the admission and exhaust tempera-

LEAKAGE THROUGH SLIDE-VALVE WITH STEAM PORTS BLOCKED AND ENGINE RUNNING.

Average Pressure. Pounds per sq. in. absolute.			Leakage in Pounds per Hour. (*a*) Lubricator working. (*b*) Lubricator stopped.					
			50 revs.		156 revs.		250 revs.	
Steam Chest.	Exhaust.	Difference.	(*a*)		(*a*)	(*b*)	(*a*)	(*b*)
35	16·25	18·75	11·6	—	11·25	14·1	10·5	13·5
45	16 75	28·25	—	18·0	—	—	—	—
63	17·00	46·00	20·6	18·4	19·50	23·4	19·5	22·5
93	18·25	74·75	30·7	28·9	27·25	30·9	26·6	29·4
145	19·75	125·25	45·0	38·1	42 75	40·3	41·2	—

tures. It should be noted that while the difference of temperature was practically the same in each series of tests, the condensation increased with increase of temperature in a much higher ratio in the jacketed than in the non-jacketed trials. Considering this fact in connection with results obtained at different speeds and with different temperatures, Professor Capper draws the conclusion that "the losses due to condensation on the cylinder walls of unjacketed engines diminish with increased initial pressure and temperature for a given ratio of expansion quite independently of the influence of speed."

With one or two exceptions, total condensation decreased with increase of speed, alike in the jacketed and non-jacketed series. During expansion the steam re-evaporated attained a maximum value of about 3·5 lb. per 1,000 strokes, and it should be observed that this applied to both series of trials, and also that jacketing had little influence upon evaporation during expansion even at the low speeds when the engine in a jacketed condition was more economical than when unjacketed.

The temperature entropy diagrams, to which we have already alluded, are of much interest. The superimposed diagrams for constant temperature and varying speeds show that the proportion of steam present, both at cut-off and at release, increased in regular sequence with the speed, this result being specially marked in the trials conducted with the higher standards of temperature. In the first series, the effect of jacketing is made very apparent, all the expansion lines being much closer to the theoretical saturation curve than in the diagrams relating to the unjacketed trials. The higher temperatures show that jacketing so far affected results as to justify the inference that initial condensation depended less upon speed than upon accidental conditions of the trials. Hence, jacketing appears to eliminate the effect of speed upon percentage initial condensation.

Although it would not be justifiable to deduce general conclusions from trials upon one particular type of engine run under one set of conditions, we must congratulate Professor Capper and his able assistants upon the consistent and definite character of the data obtained so far. The conditions under which the trials were conducted have permitted the analysis of results in a manner that will prove most helpful to all designers of steam engines.

Among the more valuable of the indications afforded by the analyses are the following :—

(1) That leakage through the slide valve, now quantatively determined for the first time, is shown to be practically independent of the speed of the sliding surface, directly proportional to the difference of pressure between the two slides of the valve, and, to an approximate extent, inversely proportional to the overlap of the valve.

(2) That even with well-fitted slide valves the leakage may represent more than 20 per cent., and is rarely less than 4 per cent., of the total steam entering the cylinder.

(3) That, in an unjacketed engine with given ratio of expansion, the percentage initial condensation diminishes with increase of initial temperature, while the total condensation per stroke increases with increase of unit temperature.

(4) That for a given ratio of expansion, the re-evaporation of steam is at least as marked in a non-jacketed cylinder as in one that is jacketed.

(5) That from the results obtained it is possible to determine the temperature at which, for any speed of revolution with a given rate of expansion, jacketing may become unnecessary and even wasteful.

In conclusion, we may remark that this document has involved arduous work extending over six years, and we feel sure that our readers will agree with us that, although dealing with only a small part of the subject awaiting investigation, the report constitutes a most valuable addition to our present knowledge.

Electric Motor Drives by Belting.

By E. Kilburn Scott, M.I.E.E., A.M.Inst.C.E.

When, by repeated tests, it became known that large amounts of power were being wasted by belt and rope driving in workshops and factories, a craze for direct coupling of motors, or the employment of gear wheels for reducing speed, set in, and it has not yet spent itself. The disadvantages of long drives from room to room between countershafts was from the first self-evident; and in these days of electric motors there is no excuse for such waste. The utter condemnation of all belt driving, however, is very foolish, for, of all methods of transmitting power in small amounts and for short distances, belting is far and away the cheapest and easiest to apply. To show how these matters work in cycles, one may very well refer to the wooden pulleys which are now so popular. It is safe to say that the first pulleys made in prehistoric engineering were of wood; then came cast iron, and afterwards wrought iron and steel, and now the wooden pulley is resuscitated, and everybody wonders why we used anything else, as it is so obvious that the grip would be better.

The whole question of driving of machinery is essentially millwright work, and the man who has spent his time in electrical or even regular engine building or other mechanical work, is liable to be widely out. Millwrighting is a distinct trade to itself, and depends on actual experience more than any other branch of engineering activity. Every kind of machinery, whether cutting tools, printing, textile, flour milling, etc., presents quite distinct problems. To show how little some men who instal electric motors know of the elements of millwrighting, they will calmly dispense with a long line of shafting, pulleys, and belts, which are equivalent to many small flywheels, and will install a few motors running at high speed and with practically no weight in their armatures. When the motors break they wonder why, forgetting that the nearer they go to individual driving the more is the unequal loading of the machines felt by the motor and the greater the need for fly-wheel powers. Clearly, the more machines there are driven from one point, the more equable will be the load, for the inequalities of the various machinery will cancel out to a large extent.

A Miehle printing press, for instance, for sheets 60 in. by 40 in., requires a 5 h.p. or 6 h.p. motor; and, when running at full speed, the power jumps from zero to maximum no less than 300 times a minute—that is to say, at each reversal of the table. The problem, therefore, is really a much more difficult one than the driving of a planing machine, for although the metal planer may require a large motor, the number of reversals is not anything like so frequent. It is true that in these Miehle and other high-speed presses it is customary to fit them with air buffers to take up the momentum at each end of the stroke, but even so there is considerable jar on the mechanism.

Now, a belt between the motor and the machine forms an elastic medium through which the jar can expend itself; and in case of anything going wrong with the machine, it forms an exceedingly good automatic overload device, for if anything serious happens, the belt comes off. This overload device partakes of the nature of a fuse without its disadvantages; that is to say, it has a time element, and does not come off immediately the current exceeds a certain amount, which is such a nuisance with the magnetic overload switch. It is a too well-known fact that both magnetic overload switches and fuses are liable to be misused by the machine attendant, for if the magnetic cut-out comes out too fre-

quently to suit him, he will as often as not screw it up too far, and, in the case of fuses, he substitutes copper wire.

In the case of a belt, there is no possibility of the attendant faking the conditions; and, to the average man, a belt coming off is a more serious matter than a switch or a fuse going; it appeals to him much more than the vagaries of any electrical apparatus.

Where the drive is short, the raw hide cemented belt is an excellent type to use. It has a good bite on the pulley, even when slack, and the double leather belt is only $\frac{1}{4}$ in. thick, so that it can be used on pulleys of quite small diameter. For a press such as we have been considering, a belt about 5 in. wide would be suitable, and there the drive is about 4 ft. centres, such a belt can be obtained for under £2, whereas a raw hide pinion and wheel, with cut teeth, would probably cost nearer £10. The raw hide pinion would require to be renewed much more frequently than the belt.

One great advantage of driving by belting is that the centres between the motor and the driving shaft are not to half an inch or so, and with the motor on slide rails it can be easily adjusted to any degree of tightness. As a matter of fact, a raw hide belt is generally bought as a complete belt already cemented, and there is practically no extension after it has once been set to work, so that the motor does not even require occasional adjustment. In the case of gearing, the centres must be made exact, and often this means that the motor has to be placed in a position where it is in the way, whereas, with a belt drive, the belt can be lengthened or shortened until the motor is in such a position that it is not in the way.

In an ordinary press, for example, where the driving shaft is in the centre, the motor can be very well fixed on slide rails at one end, underneath the feeding table. In this way, many more machines can be got into a room of given dimensions and yet leave ample gangways between them.

Another advantage of the belt is that the ratio between the speeds of the motor and the driven shaft can be very much higher than is possible with gearing: a pinion will not work properly unless it has fifteen teeth, and therefore with a ration of over five to one, and so on, the wheels become very large. With raw hide belting it is possible to have a ratio of speeds of eight to one, and drives as short as a couple of feet for one horse-power.

It is sometimes said that belts give a side pull on the bearings, but, as a matter of fact, if the belt is properly proportioned to the pulley, that is to say, if it is thin and the pulleys relatively large and the drive of suitable length, the side pull is not such as to cause trouble, even with a badly-proportioned bearing. Certainly the side pull has its *contra* in the thrust between centres with gear wheels, for the tendency of wheel teeth is to force the centres apart.

Even where a wide variation of speed is required, there is much to be said for the long speed cone, or other mechanical speed changing device, because then the electric motor can then be kept running at or near full speed, and therefore at full power. Where motor speeds are reduced, then the power is reduced also, and this at the very time when power is most required. Tinkering with motor speeds also usually means greater tendency to sparking, and a much larger and more expensive motor and controller.

In the case of a three-phase motor, there is difficulty in obtaining changes of speed, and this is often put forward as a great disadvantage. As a matter of fact, it is no real disadvantage at all, as is conclusively shown by the fact that some of the most important and complete motor driving installations in the world are entirely driven by three-phase motors —the British Westinghouse Works, at Manchester, and the fine work of the Allgemeinne Elektricitats Gesellschaft, of Berlin, to mention only two.

ELECTRICAL NOTES

By Andrew Stewart, A.M.I.E.E.

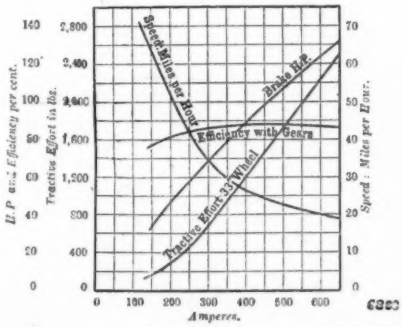
Single Phase Electric Traction on the Indianapolis-Cincinnati Railway.*

In view of the recent decision to electrify a small portion of the London, Brighton and South Coast Railway, and to employ single phase motors on the trains, with the overhead system, the following description of the first American line working with this system, on a commercial scale, will be read with interest.

The power house equipment consists of three Babcock-Wilcox boilers fired with natural gas, though provision is made for using coal, should the supply of the former prove insufficient; in the engine room there are two 700 h.p. cross-compound Corliss engines direct connected to two 500 kilowatt, 2,300 volt, three phase 25-cycle generators: the three phase current is changed to two phase and transformed up to 33,000 volts, at which pressure it is distributed to the sub-stations along the line. At present some 41 miles of track has been laid, and transformer sub-stations, each equipped with two 300 kilowatt oil insulated transformers, have been erected 10 to 12 miles apart, transforming down to 3,300 volts, which is the pressure at the trolley wire. There are no switches or circuit breakers in these sub-stations, all the control being at the main switchboard in the power house, hence labour at the sub-stations is unnecessary. To facilitate the working of the trains two telephone lines, which have a metallic circuit, are carried on the trolley poles, one line for general purposes and another used exclusively by the train dispatcher. Each car has a telephone, and the conductor can communicate with the train dispatcher from jack boxes placed on the trolley poles every 2,000 feet. The line is laid with 70 lb. T-rails, having the usual bonded joints, cross bonds are put in at every half mile. The poles carrying the trolley wire are of wood (white cedar), 40 ft. long, with 6 ft. buried in the ground, spaced 100 ft. apart. The trolley wire is carried from a $\frac{7}{16}$ stranded steel cable, to which it is fixed by steel clamps every ten feet. The trolley wire is 18 ft. above the rail level. The rolling stock consists of ten passenger cars 55 ft. over all, divided into three compartments—luggage, smoking and ordinary; total accommonation per car, 54 passengers. The car has two trucks each with two 75 h.p. Westinghouse single phase motors; the general performance of these are shown (Fig. 1*.) The control is rheostatic, and the motors may be operated with either alternating or direct current; in fact, the cars are run over three miles of 550 volt direct current system in Indianopolis. The gearing is for 45 miles per hour maximum, and an average of 30 m.p.h. is maintained. The car has two trolleys, one an ordinary wheel trolley for use in Indianopolis, and a bow trolley more suitable for high speed outside the city. Special cars to maintain 50-60 m.p.h. equipped with four 150 h.p. motors are being built. The car connections are shown diagramatically (Fig. 2). The auto-transformer is connected between trolley wire and the rails; from points giving suitable pressure, two separate circuits are tapped off, one giving 500 and the other 200 volts. The former goes to the primary, and the latter to the secondary, of an induction regulator, which enables the voltage to be varied between a few volts and the full motor voltage of 500 to 600 volts. The speed is reversed by the reverse switch shown. The results so far have been very satisfactory.

* *The Electrician*, March 3rd, 1905.

* From H. L. Riseley's paper to the Newcastle Section Inst. E.E., January 16th.



CE CURVES, NO. 91, WEST.NGHOUSE A.C. RA'LWAY MOTOR.

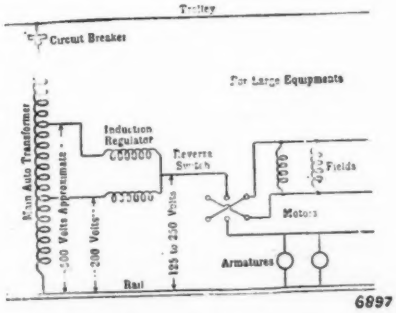


FIG. 2.—DIAGRAM OF MOTOR CIRCUIT.

High Speed Electric Railway Propositions in Germany.*

SINCE the now well-known Marienfeld Zossen experiments in 1902-3, the question of a high-speed line from Berlin to Hamburg has been seriously discussed. Our readers will remember that it was then demonstrated that 120 miles per hour was quite safe on a good track, though the energy required was enormous, for instance, a 60-passenger car at 110 miles per hour, required 1,300 h.p., which, however, increased to 2,000 h.p. at 120 m.p.h.; 1,100 h.p. being necessary to overcome air resistance alone, at the latter speed. Light cars were found impracticable at over 80 m.p.h., and curves must have a radius of at least a mile if full speed is to be maintained in rounding them. Based on these results, Messrs. Siemens and Halske, and the Allgemeine Elektricitäts Gesellschaft have submitted proposals for a line from Berlin to Hamburg, the distance is at present 177 miles, which could possibly be reduced to 155 miles by a new route, fast steam trains make the journey in 3½ hours, the present fare is 15s. 9d., and the annual traffic is about 440,000 passengers. The two proposals are summarised below :—

	Siemens and Halske	Allegemeine Elektricitäts Gesellschaft.
Line	Single Track.	Double Track.
Speed..	83 m.p.h.	100 m.p.h.
Time of Trip ..	1 h. 55 m.	1 h 25 m.
Capital Cost of Line	£3,330,000	£5,950,000
Average fare ..	15s.	15s.
No. of passengers at average fare, necessary to show profit over working and capital expenses. ..	520,000	850,000

The Allgemeine Company make an alternative proposal of a line with equipment to run at 125 miles per hour, and do the journey between the two cities in 1 hour 14 mins., but the capital cost becomes £7,140,000. It is considered unlikely that the German Government will undertake the construction of the line, as it will compete with, and reduce the earning power of the existing State railway; nevertheless, the proposals are interesting as showing what a high speed trunk line would cost.

The Present Status of Electric Furnace Working.†

AN abstract of a paper read by Prof. Chas. F. Burgess to the Western Society of Engineers, Chicago, in which the lecturer said that since the introduction of the electric furnace by Sir William Siemens twenty-five years ago, a new chemistry of high temperatures has been evolved, magnesia, tungsten, and similar substances hitherto considered infusible, have been melted in the electric furnace, and all the oxides formerly considered irreducible have been reduced in it. The most striking industrial application of the electric furnace at the present time is the production of aluminium, reducing its price to one-sixteenth of its former value. The chief advantage of the electric furnace is not only its high temperature, but the fact that the heat may be developed in a compact and limited space. A recent design of a furnace avoids the use of electrodes, and uses the material in the furnace as the secondary of a transformer, only materials possessing electric conductivity can be used in such a furnace. A commercial efficiency of 75 per cent. is easily obtained in furnaces ranging in size from 200 to 1,000 h.p., which is much superior to the reverberatory furnace for pig iron, which has an efficiency of only 8·5 per cent. During the discussion it was stated by Professor Jackson, of Wisconsin University, that the electric furnace would ultimately revolutionise manufacturing processes, and by reducing the cost of producing many metals, change the value of commodities.

* *Electrical Review*, New York, February 11th, 1905.

† *The Electrical World and Engineer*, New York, February 11th, 1905.

This series of notes and abstracts, which will in future form a regular feature of the *Engineering Review*, are intended more particularly for the general engineer who wishes to maintain at least a general acquaintance with the developments taking place in the department of electrical engineering.

The Ventilation of Coal Mines and Underground Spaces by Mechanical Means.—I.

By STEPHEN H. TERRY, M.Inst.C.E., M.I.Mech.E.

To find some method by which coal mines can be economically ventilated with absolute certainty under all atmospheric conditions is a problem which has engaged the attention of colliery managers and mechanical engineers during half a century. The cost of ventilation bears only a small proportion to the total expenditure in working collieries, but its efficiency is of the utmost importance, and, in these days of keen competition, economy, when combined with efficiency, must not be lost sight of. Chimney draught naturally suggested to the early colliery engineers a means of ventilation, and underground furnaces in collieries where natural ventilation was insufficient became at one time universal. Dismissing from this paper, as unworthy of consideration, the natural ventilation of coal mines—as such natural ventilation is not to be relied on during times of low barometer, which is just when it is most needed—we will proceed to points in connection with furnace ventilation. The disadvantages of these are, first, the incomplete control of the volume of air passing into the mine; second, the fouling of the up-cast shaft by the products of combustion of the underground furnaces; third, the undue warming of the steel winding rope, if this be fixed in the up-cast shaft; fourth, waste of fuel; fifth, danger from fire; sixth, danger of explosion. It has been found in connection with the first objection that the greatest volume of air is required at a time of low barometer or of high thermometer; and as it is during these periods, especially those of low barometer, that the largest volume of fire damp escapes from the seams and working faces of the colliery, thus needing the largest volume of fresh air to render the mixture inexplosive, it is precisely at these periods that ventilation by furnace, like natural ventilation, is the least efficient. Objection No. 2.—The fouling of the up-cast shaft is inconvenient to those employed in the pit, not merely when used for winding minerals or men, but also in the event of repairs being required in the shaft, either to the tubbing, guides, pump gear, water, or steam pipes. If steam is taken down the pit to hauling engines, it is preferable that the pipes should be placed in the up-cast shaft, as the heat radiated from them assists the ventilation; whereas, if taken down the down-cast shaft, the steam pipes would retard the ventilation. In these days there are also the electric light wires to be considered, and repairs to any one or to all of these systems are rendered doubly difficult when conducted in the atmosphere of a chimney. Objection No. 3.—In cases where the winding machinery is fitted in the up-cast shaft, the steel rope is rendered by the furnace below much warmer than its temperature when wound on the drum; the consequence of this is that the steel rope is constantly contracting during cooling on the drum, thereby causing severe strains, necessitating the making of the drum of enormous strength, and gradually injuring both the wood lagging and the rope itself. If the rope, when in the shaft, is only exposed to the same temperature as that when it is on the drum, no contraction takes place. Objection No. 4.—This objection is perhaps as powerful as any of the foregoing, as it has been proved that a given weight of fuel consumed in a suitable boiler furnace producing dry steam, supplying an economical compound engine driving a properly designed fan, will move some dozen

times the volume of air and at a higher water gauge than if the fuel were burnt on the best designed furnaces on the system of furnace ventilation at the bottom of the shaft. Objection No. 5.—Danger of Fire.—The risk from furnace ventilation, as long as all working doors below ground remain in good order, and as long as no sudden fall of the roof, or slight explosion, reverses the current of air, is probably small; but if any of these events occur there is great danger that the mine may be fired by the underground furnace, and in former days, and occasionally in recent times, such accidents have occurred. The same remarks apply to the danger of explosion. Theoretically, there is no risk of explosion from an underground furnace, as the air from the mine is not allowed to mingle with the products of combustion until after all flame has ceased. Practically, these conditions cannot always be ensured, the truth being that the flow of gases through underground passages obeys the unalterable laws of nature, and not the wishes of man, or his imperfect interpretation of those laws. It is, therefore, obviously safer to have no dealings with fire when explosive gases are under consideration. From the above reasons it will be seen that there is a strong argument in favour of moving air for ventilating collieries by mechanical means, rather than by the direct application of heat through the medium of a furnace. To attain this end, various forms of apparatus, more or less connected with the principle of action of a suction pump, were used in early days. Steam jets and jets of water have also been used, but with the rapid progress towards perfection of mechanical science during the past fifty years, centrifugal fans have taken the place, except in one or two instances, of all other mechanical appliances for the ventilation of collieries. I have said "of all other mechanical appliances" because, strange as it may seem, there are still a large number of fiery pits ventilated by furnaces. Some of these pits also use petroleum engines underground, and in three cases disastrous results have followed their use. It would seem that in any pit where, from the large volume of gas present, it becomes necessary to use safety-lamps, common sense should also dictate that no petroleum engines or open flame of any kind should be admissible. Admitting that fans are now the recognized methods of ventilating collieries conducted on the best and most modern system, it has hitherto been thought desirable that these fans should be of large diameter, from 30 to 45 and even 50 feet, in order to avoid the necessity for rapid revolution where large volumes of air have to be passed.

The important factor in the question of speed is not so much the number of revolutions per minute at which the fan ought to run as that of the rate at which the engine can run, doing continuous work for months together without stopping or slowing down.

This speed has until recently been thought to be something between 30 and 70 revolutions per minute, 40 to 45 revolutions being a very general speed. If a direct-driven fan be thus tied down in speed by its partner the engine, it is obvious that to deal with a large volume of air at high water gauge it is necessary that the fan be of large diameter, and as a consequence we have fans up to 50 ft. in diameter, running at a peripheral speed of 60 to 70 miles an hour. Even at this moderate speed of turning, it is found that, in consequence of the great size and weight of the parts comprising the fan, considerable strains are produced, thus leading to the necessity for very great strength, rigidity, and cost in construction; the first cost of fan and engine, and the costly brickwork structure necessary for these large fans being almost directly in proportion to their size. Many a colliery engineer and owner has hesitated to incur the capital outlay necessary, and has continued to put his trust in the unsatisfactory system of furnace ventilation, with its attendant risks and inconveniences. An alternative between the costly, slow moving, large fan and furnace ventilation has presented itself in belt-

driven fans, and in some instances belt or rope driven fans of moderate size have been adopted with fairly satisfactory results; but objection may well be taken to the introduction of a belt between a prime mover and a colliery fan, the running of the latter being so absolutely essential to the working and safety of the pit. It was to avoid the uncertainty attached to belt driving that the idea was conceived of coupling a high speed engine to a fan. By this means the dimensions, weight and cost are all kept within moderate limits, and very great saving in brickwork foundations and fan casing have been effected. This satisfactory result has been obtained by the fact that with this type of engine the speed is not restricted, and consequently the fan, instead of being tied down as in an older type of ventilating plant, by the engine, to a low number of revolutions, can be run at its most economical speed, which is several times in excess of what has hitherto been obtained with direct coupled engines, and, indeed, is as fast as that obtained with many belt-driven fans, and a peripheral speed in excess of what is usual with belt-driven fans is now easy by direct driving. Thus, in a fan constructed for the Cossal Colliery, the peripheral speed is 10,000 ft. per minute; and were a higher steam pressure available, both engine and fan would be capable of running so that a peripheral speed of 130 miles per hour could be obtained. As it is due to the design and construction of the engine and fan that this high speed is obtained, it will be well to briefly describe them. The engine is of the single acting type, with piston valves and cylindrical guides for the cross-head, and slide valve rods, which are situated in the crank chamber below the bottom cylinder cover and its gland, and partake of the same lubrication as the crank-shaft and other moving parts. The cylinder cover and glands below the piston and valves serve the double purpose of keeping steam from entering the crank chamber and preventing the entry of oil, water or air into the cylinder from the crank chamber. The piston rod and slide valve glands, having only to deal with exhaust steam, run with very little packing, and do not need to be screwed up tight. All the wearing surfaces are lubricated by the running of the engine; a continuous stream of oil and water flows along the crank-shaft brasses, but is prevented from escaping at the end by an arrangement which also dispenses with glands on the crank-shaft. (Glands on crank-shafts give trouble and waste much power in friction.) On removing the doors at front and back of the engine, it becomes an open engine, and is more accessible at front and back than most open engines. This type of engine will run just as well under steam as an open engine, but it is not so well lubricated under that condition; it is therefore best to run it with the doors closed, by which a further advantage is secured, namely, the economy of oil and the exclusion of dirt; this last is a most important factor of efficiency in the vicinity of a pit bank. There are types of high speed engines which require doors to retain the steam leaking past the piston, and having no bottom cylinder covers or glands, the steam flies freely out amongst the connecting rods and cranks, and mixing with the oil in the crank chamber quickly boils it away; but in the modern closed engine not a breath of steam can reach the crank chamber. It is found that on opening an engine which has been running for some time at full speed the oil and water are in a state resembling whipped cream, thus preventing metallic contact of any of the moving parts, which are always floating on a film of oil. When the steam pressure available at collieries is sufficiently high, the engine is built tandem compound, but in the older collieries it generally happens that sufficient pressure for compounding is not to be had, it is only in modern collieries that one finds anything over 80 lb. of steam pressure, and there are numbers of closed engines running, driving colliery fans, which have a boiler pressure of 30 lb. only.

The fan consists of a central steel disc of boiler plate, mounted between two cast iron bosses bored and fitted on a massive steel shaft, to which they are keyed. On each side of this steel disc are riveted curved steel plates attached to steel angles, also curved. The curve found to give the best result is somewhat like the curve formed by a ship's bow as designed by the late Scott Russell. The air enters the fan and passes along the surface of the blades at a gradually increasing speed until it reaches the periphery equally at all parts of the circumference of the fan, the casing being spiral. The fan thus runs without shock from the entry or leaving of the air; this secures absolute silence and freedom from vibration, with its consequent loss of power. When a fan works with vibration, apart from the risk of injury to itself, there is a very great loss of power. The blades of the larger fans are rigidly steadied by radial stays passing from their outer corners to steel rings on their shaft thus, any tendency which centrifugal force may exert to distort the blades is counteracted. The outer edges of the blades run close to the casing, which may be of brickwork, or preferably of steel. One of the most powerful combined high speed engine and fans yet built is at a Nottinghamshire Colliery, and it deals with 280,000 cubic feet of air per minute at 4½ in. water gauge. It was guaranteed to do 250,000 only, but during a trial trip of some hours' duration it dealt with over 300,000 cubic feet per minute. The weight of air thus moved is very much greater than would be anticipated by those who have not given attention to the subject. Thirteen cubic feet of air at 60 deg. F., with the barometer at 30 in., weighs 1 lb. avoirdupois; hence the weight of air moved per minute is equal to 10 tons 6 cwt. 5 lb., or 618 tons, 3 cwt. per hour, or 6,180 tons in 10 hours, or in 24 hours 14,835 tons, or in one week 103,845 tons, or per annum 5,309,940 tons. It is obvious that an engine so constructed is capable of long runs, and there are many engaged in colliery fan driving which run over a year without stopping or slowing. While on the subject of volumes of air exhausted by fans and passed through colliery workings, it should be noticed that it is much more easy to take erroneous gaugings as to the velocity of the air than it is to obtain correct gaugings. In the gaugings which will be alluded to in the case of a fan in the Cannock and Rugeley Colliery, and others, each measurement of air by anemometer, instead of being taken at one or two points only in the colliery roadways, was taken in about thirty-six different places in a vertical plane across the roadway; thus each observation is really the mean of thirty-six observations, and the necessity for this is due to the fact that air in the vicinity of the sides and bottom of the roadway is naturally impeded by friction, and consequently the flow in the centre is very much faster than near the sides, top, or bottom. Neglect of this obvious fact, which has been fully noted by those experimenting on fans, has probably led to the idea that sometimes fans which have been experimented on without due allowance for this are credited with very much greater efficiency than is really their due, to the extent, perhaps, of 30 per cent. of the whole volume; this, of course, makes a very large difference in the alleged efficiency. The efficiency of a combined engine and fan is about 80 per cent. of the steam diagram.

The air from the up-cast shaft should enter the fan in parallel streams without vortices or eddies, the blades of the fan should be so shaped that the air enters them without shock. and, having passed through the fan towards the periphery in a helical course, shall attain as near as may be of the greatest centrifugal velocity as it flows away from the edges of the blades, which, if they be properly proportioned, will produce this effect without shock. To attain this result a high peripheral velocity is necessary. This can, of course, be obtained by making the fan of large diameter, coupled to a comparatively slow engine, which

means large capital expenditure, and, with the necessary brickwork, may run into £4,000 or more. The alternative is to couple a relatively small fan to a high speed engine, with which a speed of from 300 to 500 revolutions per minute can be readily maintained for months, and even years, and a peripheral velocity far in excess of that obtained with fans 40 ft. in diameter, driven by slow running engines, can be maintained; and the cost of a duplicate plant of this system would be less than a single plant of the larger size. It is seldom considered necessary to duplicate the fan if a duplicate engine be provided with suitable couplings, which couplings should, in the author's opinion, be of the clutch type, in which the real drive is by properly fitted clutches, although two through bolts may be used to hold them in position.

In a subsequent article, the author proposes to give particular instances of such appliances, and also to deal with the transit of the air through the workings of the colliery, and the use of special auxiliary fans electrically propelled, to deal with certain more inaccessible parts of the colliery.

Trials of the s.s. Coronia.

At the official trial of the new Cunarder Caronia, recently completed by John Brown & Co., Limited, of Clydebank, the following results as the mean results of four runs on the measured mile, and subsequent twelve hours' steaming were obtained:—

	Mean of four runs	Average for ensuing 12 hours.
Revolutions	89·2	... 88·3
I.H.P., port	10,986	... 10,440
„ starboard ...	10,884	... 10,610
	21,870	21,050

	Mean of four runs.	Average for ensuing 12 hours.
Boiler pressure ...	205 lb.	... 205 lb.
H.P. receiver ...	194 lb.	... 193 lb.
1st I.P. receiver ...	98 lb.	... 95 lb.
2nd I.P. receiver ...	48 lb.	... 46 lb.
L.P. receiver ...	11·5 lb.	... 11 lb.
Air pressure in ash-pits...	7 in.	... 7 in.
Mean speed of ship...	19·62 kts.	...19·45kts.

As by the terms of the contract the speed on trial was to be 19 knots, it will be seen that the vessel easily fulfilled the conditions.

Tank Engine Derailments.

By A. G. ROBINS, M.I.Mech.E.

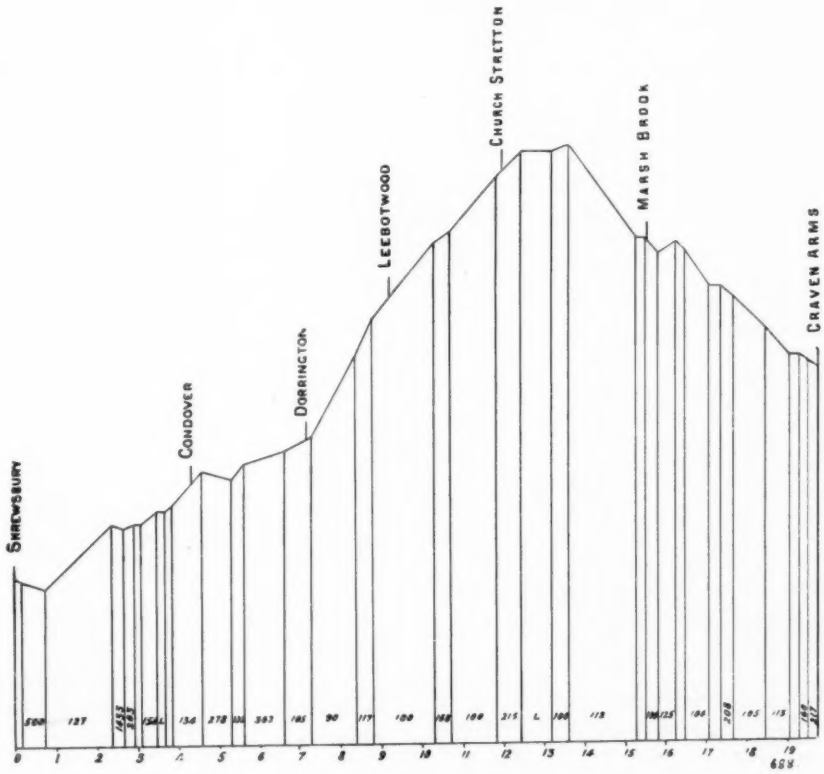
In October last an accident occurred to a Great Western express near Llanelly, when the leading engine (a six wheels coupled saddle-tank) was derailed while travelling at high speed. Two other accidents of a somewhat similar nature having occurred within the past twelve months, namely, at Tal y Cafn on the London and North-Western, and Waterloo on the Lancashire and Yorkshire Railway, in both cases the engine—a tank—running off the road for no apparent cause other than that of high speed, these accidents have brought into prominence the question as to the safety and advisability of using this type of engine for fast trains; and the matter has been discussed at length in the correspondence columns of the weekly technical journals. Colonel Yorke, in his report to the Board of Trade on the Tal y Cafn accident, summed up his opinion in the following words:—"Engines of this type cannot be regarded as express engines, and are not usually timed to run at a speed of 60 miles an hour. In view of the experience gained by the present accident, it would be advisable to limit the speed of engines of the type in question to 40 miles an hour as a maximum."

This question of the safety of running tank engines at high speed is one of considerable importance, and should be carefully considered at the present time, as, owing to the increasing competition of electric trams, there is a tendency to raise the speed of our suburban trains, in order to successfully compete with the former. Suburban trains up to within the past seven or eight years ran, say, 12 miles out, stopping at every station *en route*, and were timed to cover that distance in 45 minutes. Now they are required to run 30 miles, with two stops, in 50 minutes, or the same distance without stop in 40 minutes. Such work is to be found within the London District, though not to such an extent as prevails in and around the manufacturing districts of the North. The Lancashire and Yorkshire and the London and North-Western both own large numbers of tank engines, and work them on local trains at a high average speed, which necessitates the attainment of speeds up to 65 miles an hour. There is, to my mind, no inherent reason why a tank engine should not be perfectly capable of hauling fast trains; the absence of a tender may or may not affect its steadiness, but the real crux of the matter lies in the fact that most tank engines are not and never have been designed for running at high speed. The duty contemplated in most cases was:—(*a*) Yard shunting work; (*b*) local traffic at a maximum speed of 30 miles an hour; (*c*) banking heavy trains up such gradients as Shap, Beattock, etc.

Many years ago a class of tank engine was built for the old Bristol and Exeter Railway especially for fast traffic; they had 9 ft. driving wheels and were provided with leading and trailing bogies. Though not, perhaps, entirely successful, it is a fact that they worked express trains for years without suffering from any serious derailments on a road which nowadays would be pronounced highly unsafe. One of these engines is known to have attained a speed of 81 miles an hour.

Though it is true that few of the existing types of tank engines have been designed with a view of running at high speed, there are a good many engines which are perfectly capable of working trains timed at over 40 miles an hour; for example, the Lancashire and Yorkshire radial tanks; the Great Western No. 11 class, having four wheels coupled and leading

and trailing radial axles; the London and North-Western engines of the same type, many of which were originally built as tender engines and later converted into tanks. I have frequently travelled at high speed behind these engines and have watched their behaviour when running, and I am satisfied that all three classes may be safely run over a good road at any speed up to 65 miles an hour. To anyone who doubts this statement, I would recommend a few trips from Buxton to Stockport by one of the non stopping trains of the London and North-Western Railway. That a well-designed tank engine can safely travel at high speed is a fact which daily experience has proved beyond question. I will quote one instance which occurred within the last twelve months, and of which I made notes at the time. The line known as the Central Wales section of the London and North-Western is a difficult one to work, as the gradients are steep, the curves bad, and for 47 miles of its length there is but a single road. The trains are worked



Vertical Scale 1 inch = 80 feet

Horizontal Scale 1/4 " = 1 mile

GRADIENT PROFILE, L. AND N.W. RAILWAY, SHREWSBURY—CRAVEN ARMS.

by all sorts of engines—tanks, goods, and express—but chiefly the former. Owing to the necessarily slow running over the single line portion from Llandovery to Knighton, the best trains are timed as real expresses thence to Shrewsbury, the booked speed from Craven Arms being as high as 47.7 miles per hour. The train on the day in question consisted of six coaches (three being 8-wheel bogies), weighing altogether about 125 tons, and was drawn by a four wheels coupled tank engine with radial leading and trailing wheels. From Knighton to Craven Arms the road is mostly downhill, and we soon reached 60 miles an hour. This speed was maintained pretty evenly all the way, though for one quarter mile it exceeded 70 and we were stopped by signal outside Craven Arms, having run the $11\frac{3}{4}$ miles in 14 min. 20 sec. = 49.1 m.p.h.

From Craven Arms the line rises continuously for nearly seven miles at about 1 in 112, and up this bank our engine averaged 36 miles an hour, the actual speed on the worst part of the bank being over 40. Then followed the long descent into Shrewsbury, and here the tank engine proceeded to run at a speed which is rarely exceeded by the Severn Tunnel expresses on the same line. Sixty miles an hour was soon reached, and, still accelerating, the chronograph registered alternate quarter-miles at 72, 75, and 75.6 miles per hour. The eight miles from post 12 to 4 averaged exactly 64 miles an hour. A series of signal checks and a final stop outside Shrewsbury spoilt what would have been a smart piece of running, though even so the average speed to the signal stop was 46.7. The accompanying profile shows the gradients of the line in question.

LONDON AND NORTH-WESTERN RAILWAY.

CENTRAL WALES EXPRESS.

Miles.	Stations and Mileposts.		Booked Time.	Actual Time.	Speed
	Knighton.	dep.	2.44	3 0 25	
	Mile post 9.	pass		3 5 5	
	,, ,, 6.	,, ...		3 8 0	61.7
	,, ,, 2.	,, ...		3 12 5	58.7
$11\frac{3}{4}$	Craven Arms Home Signal.	arr.		3 14 45	
$12\frac{1}{4}$	,, ,,	Station. arr. ...	3.2	3 16 25	
	,, ,,	,, dep. ...	3.5	3 18 30	
	Mile Post 18.	pass		3 22 40	
$18\frac{3}{4}$	Church Stretton.	pass ...	...	3 30 25	40.6
	Mile Post 12.	pass		3 31 8	
	,, ,, 4.	,, ...		3 38 40	64
$30\frac{1}{4}$	,, ,, 1.	(Signal). arr. ...		3 42 45	
$31\frac{1}{2}$	Shrewsbury.	arr.	3.22	3 46 50	

I have dealt with this run in some detail because I think an ounce of practice is often worth a ton of theory. This train runs throughout the year—not in summer only—and it is almost always worked by a tank engine. The time allowed from Craven Arms to Shrewsbury is 27 minutes; yet, though we ran 40 miles an hour uphill and 75 down, booked time would only just have been kept had the road been clear. I do not, of course, wish to infer that this train runs daily at such a high speed, but that it runs day after day at 60 to 65 miles an hour is an undoubted fact; and there are other portions of the North-Western system—as, for instance, between Stafford and Crewe—where these same tank engines are worked on fast trains at an average booked speed which involves considerably over 60 miles an hour if time is to be kept; and this brings one back to the original proposition: Is it safe to run tank engines at express speed? To this I unhesitatingly answer: Yes, if such engines are properly designed. A six coupled saddle-tank engine such as was used on the Great Western express at Llanally is not and never can be regarded as a fit and proper type for such work, nor are engines having leading wheels coupled and a single trailing axle any better in this respect. There are numerous engines having four wheels coupled, a single leading axle and a long overhang at both ends, the cylinders and even the front tube plate being fixed ahead of the leading wheels. Such engines, when driven at high speed set up a pitching motion like a ship in a head sea, and, besides being unsafe, do considerable damage to the permanent way. As to why some tanks run easily at high speed and others do not, it is very difficult to determine; personally, I believe it is largely a question of balance or an even and symmetrical distribution of weights.

The wheel base should be long; in many types it is quite insufficient, and I have in remembrance the extraordinary difference in the running of two small engines built for a 15 in. gauge light railway, where the addition of about a foot in the length of wheel base gave infinitely smoother running.

It is a fact that two of the accidents mentioned above, namely, at Tal y Cafn and at Waterloo, occurred to engines which I should describe as eminently suitable for fast running; but in both cases it is by no means certain what was the actual cause of derailment. In neither case could the train have been running at a higher speed than 60 miles an hour, and even that figure is highly improbable; but, speaking with an intimate knowledge of the road in both cases, I can only give my own opinion that 60 miles an hour would not be a dangerous speed at which to run such engines, and I feel convinced that some cause other than that of high speed was at the bottom of each disaster.

The following is a summary of the principal dimensions of the engines to which I have referred:—

BRISTOL AND EXETER RAILWAY (1853).

Cylinders	16 in. × 24 in.
Wheels (driving)	9 ft. diam.
,, (bogie)	4 ft.
Weight	42 tons

LONDON AND NORTH WESTERN.

Cylinders	17 in. × 24 in.
Wheels (driving)	5 ft. 6 in.
,, (leading and trailing)	3 ft. 9 in.
Wheel-base	22 ft. 5 in.
Weight	50 tons 10 cwt.

LANCASHIRE AND YORKSHIRE.

Cylinders	18 in. × 26 in.
Wheels (driving)	5 ft. 8 in.
,, (leading and trailing)	3 ft. 7 in.
Wheel-base	24 ft. 4 in.
Weight	55 tons 19 cwt.

GREAT WESTERN.

Cylinders	18 in. × 26 in.
Wheels (driving)	5 ft. 2 in.
,, (leading and trailing)	3 ft. 7 in.
Weight	65 tons 4 cwt.

I may conclude by adding the dimensions of two types which I consider eminently suitable for running at high speed and working trains times at 50 miles an hour and over:—

LONDON, TILBURY AND SOUTHEND.

Cylinders	17 in. × 26 in.
Wheels (driving)	6 ft. 6 in.
,, (bogie)	3 ft. 6 in.
,, (trailing)	3 ft. 6 in.
Weight	63 tons

GREAT CENTRAL.

Cylinders	18 in. × 26 in.
Wheels (driving)	5 ft. 7 in.
,, (bogie)	3 ft. 6 in.
,, (trailing)	3 ft. 9 in.
Weight	

Valve Motion and Locomotive Failures.

IN a recent address before the students of Ames College, Mr. Robert Quayle expressed the opinion that more engine failures, so far as relates to machinery, were caused to-day by improper distribution of steam than by anything else; and his faith in this opinion was strengthened through the fact that there was a locomotive on his road that had a different valve motion from the other engines. It was designed on the Corliss principle—a rocking valve. This engine had been out of the shops for about thirteen months, and had made, to date, about 96,000 miles, and had not had an engine failure due to machinery since it had been out of the shops; and the mileage made to 1-16 in. wear of tire was a little better than twice as much as was made by other engines of the same class, as well as being in the same kind of service, the only exception being the valve motion. This was not only true of the tire, but it was true of the entire valve motion including the pins that operated the valves. After thirteen months of service the tool marks were not worn out on the eccentrics and links, rocker boxes, etc.; and in looking for the cause of this he found that it was due to a more even distribution of steam. This appeared to open up a grand opportunity for decreasing engine failures as well as reducing the cost of maintenance.

A Study of the Causes of Coast Erosion.

By Dr. JOHN SWITZER OWENS, B.A., A.M.Inst.C.E., F.R.G.S., etc.

(Third Article.)

In a study of this kind there are certain fundamental principles which must be kept clearly before the mind. It will facilitate matters if I mention two of the most important in the present connection:—

The first is that all movement of material, whether sand, shingle, rocks, or whatever it may be, upon the foreshore or sea bottom takes place from the surface, *i.e.*, the particles on the surface exposed to the water are first removed, thus allowing the sea to attack those beneath; the movement is not a bodily shifting of masses of material, but a molecular shifting of the individual particles composing the mass.

The other principle referred to is that there is practically no such thing as "static" equilibrium of a foreshore or beach. When a shore is met with which is in apparent equilibrium, neither erosion nor accumulation apparently going on, it does not follow that these are absent, but simply that they balance each other. The surface layers are in constant movement to and fro along the shore, up and down with the tides and waves; material may be added and taken away, and all we can say is that in such places the quantity taken away is balanced by an equivalent amount added.

One of the most important factors to be considered as influencing the action of waves, currents, etc., upon any particular place is the conformation of the coast. When it is remembered that anything which is capable of disturbing the balance above referred to will certainly produce relative erosion or accumulation, as the case may be, it will be clear that the effect of obstructions upon the foreshore headlands, a break in the continuity of the coastline, etc., such as will interfere with the littoral drift, must be very important.

Take the case of a headland projecting into moderately deep water; from whichever side the preponderating drift of material comes, when it reaches the headland, the along-shore movement is abruptly checked. The sand, etc., may accumulate in great quantities upon that side, or it may be carried round the point by currents and spread out in a long "banner" spit to the lee of it; but whatever becomes of it, you will almost invariably find erosion going on at the other side of that headland; the supply is simply diverted, and there is nothing to make up for the loses due to attrition and erosion. It is quite useless erecting groynes here, because there is no material to catch; it must be dealt with in some other way, if at all.

An excellent example of erosion due to such a cause is to be seen at St. Margaret's Bay, near Dover, near which the recent heavy landslips took place. The projection of the great chalk cliffs on the Dover side of the bay effectually traps the moving material or directs it seaward to form a "bar." In this case, it is just possible that the drift might be intercepted at the other horn of the bay, but not in the bay itself. We will now consider the case of a large river cutting through the coastline and destroying its continuity.

If there is a drift of material alongshore, under the influence of wind or tide, when the drift encounters the river mouth it is simply trapped, and carried, perhaps, out to sea; or, if it is a tidal river and the current is setting in with the tide, it is carried up the river to form shoals and sandbanks. In this case, again, we often get the "bar" formed, due to a great extent to this cause. But, from our present

point of view, it is clear that this drift, being intercepted on one bank, if it commences again on the other side, as is most probable, with nothing coming in to fill the place of that which is removed, we get erosion. In the case of small streams, this along-shore drift is often sufficient to divert the course of the stream for several miles, the spit growing out steadily on the one side, forcing the river more and more out of its course, until eventually it has its outfall perhaps miles from its original mouth. There are many instances of this to be met with, especially on the Norfolk coast, *e.g.*, the Yare and the Alde and Ore; and there is a great tendency to erosion on the mainland opposite the end of such sand spits, owing to the diversion of the river current along-shore, and also, in some cases, to the increased tidal capacity of the river, given to it by the projection of the sand spit, producing a greater and greater influx and eflux of water on each flood and ebb. I have come across a case like this on the Norfolk coast, where the erosion was entirely traceable to this cause.

There are also peculiar conformations of coast-line which allow of a certain part being sheltered from particular winds, which are very active in eroding material from the other parts of the coast. In such a case we may have drift commencing at the particular point where the shelter of, say, a headland ceases to be effective, producing severe erosion about

FIG. 1.—Showing the effect of a rough bottom on a current flowing over it; from each obstruction the water is deflected upwards in swirls, hence in a shallow stream, as here seen, the surface is lifted into hills by the natural movement of the water. In deeper water the result is an upward swirling motion of the bottom layers, light matter in suspension being thus prevented from settling.

FIG. 2.—Example of an isolated and jagged coastline. Note the curious arrangement of the strata on the projecting rock, giving a natural protection from the sea.

that point, owing to the absence of drift from the other side to fill the place of the eroded material. In many places such "critical points" are well recognized; their existence is, of course, often due to causes other than the above.

The general tendency of the sea is to plane down the headlands and projections and fill up the bays or hollows, so as to reduce the coast to a more or less uniform curve. The action of oblique waves explained in Article No. I. serves to show one reason, at least, why this is so. The waves, which are rolling in parallel to the general coast-line, will be oblique to the flanks of headlands, and so tend to drift the beach, etc., from the points to the hollows. This planing down of projections is also due to tidal currents, the eroding action of such being always more intense on the seaward end of points. There is a remarkable difference to be noted here between the behaviour of the sea and that of a river eroding its alluvial channel: the latter always tends to cut away at the concave banks and add to the convex, thus increasing the sinuosity; this effect being intimately connected with the centrifugal force developed owing to the curved path of the water.

Whenever the coast-line is jagged and indented, we always find such coast composed of rock and softer matter, unless, in course of time, the latter has been removed by the waves and currents; the rock being more resistant and remaining in great jagged teeth projecting out to sea. This is seen well marked upon the south-west coast of Ireland. On the contrary, when the coast has a smooth even outline, free from pronounced irregularities, it is usually composed of more or less homogenous material of a softer and more easily eroded nature, as, for

example, the coast of Norfolk south of the Wash, and the Holderness coast of Yorkshire.

The nature of the material composing the coast has a very important influence on the question of erosion, as has also the nature of the surface of the foreshore and sea bed adjoining. A rough, boulder-strewn beach and sea bed will of itself tend to prevent the precipitation of sand which may be held in suspension in the water flowing over it, the bottom layers of water being thrown into violent swirls and eddies, which are projected upwards from each boulder or irregularity, thus not only preventing the sand from being deposited, but even assisting to pick up from the bottom any which may already be there.

I have known of a case in which, to prevent sea-encroachment, a long line of heavy rocks was deposited upon the bottom seaward of L.W.M., the result being, if anything, to aggravate the trouble, until some years later those same rocks had to be blasted away and removed at great expense, their removal resulting in an immediate and distinct improvement in the condition of the foreshore. There is an interesting point worth considering in this connection arising out of the different mode of transport by the sea of sand, mud, etc., and heavier or coarser material such as shingle. The shingle, which travels altogether along the bottom, might be trapped and held by these very obstructions which tend to keep the sand in eddying suspension, so that in any particular case it is necessary to consider carefully whether the supply to build up a shore is chiefly shingle, or fine matter such as sand, before deciding upon the removal of bottom irregularities.

The effect of outlying shoals and rocks is also very important, both in their bearing upon current action and wave action, and it is quite possible that the gradual development of a shoal seaward of any particular place, if near enough to divert the tidal currents, will have a very marked influence on the rate of encroachment at that place. When the position of the shoal

FIG. 3.—This photograph shows the enormous force of storm waves very well. The mass of water projected skywards exercises a most powerful erosive action on falling.

is such as to give no shelter from the most severe waves, while diverting the tidal currents landward, the effect is aggravated.

A shoal or rock lying only a short distance from the shore, often, however, affords considerable shelter from the heaviest seas, with the result, in this case, that there is often a sand spit formed connecting the outlying rock with the mainland. This is due, to a great extent, to the shelter given by the rock rendering the water between it and the shore calmer than that at either side, with the result that, when there is a current flowing parallel to the shore, it picks up sand from the more disturbed areas and deposits it in the less agitated water sheltered by the rock, thus producing a ridge under the water, connecting it with the shore. Once this is formed there is a greater tendency still to silt up, as the gradient from the summit of the ridge towards either side tends to stop the material which is moving along the comparatively level bottom when it reaches the gradient.

Another cause of the silting is to be found in the behaviour of oblique waves produced by along-shore winds when such a shoal or rock is met with. Reference to Fig. 4 will explain this effect. The shore-line is represented by the line *DAB*. An oblique wave, *DG*, is supposed to have arrived at the windward end of the rock or shoal; the wave is divided by the obstruction into three sections, as follows:—*DE* passing to windward, *EF* striking, and *FG* passing to leeward of the rock. *EF* is destroyed and *DE* rolls on to strike the mainland, say, from *D* to *A*; *A*, therefore, being the point up to which the wave can produce its along-shore drift, *A* to *B* is sheltered and has no such drift, which does not commence again till *FG* strikes beyond *B*.

We get, thus, a constant feeding in along the line *EA*, with no removal, and consequently a tendency to form a beach connecting those parts. With the wind from the opposite direction, the same conditions hold good, the only difference being that the accumulation occurs along a line connecting the other end of the rock or shoal with the shore. This effect can be seen even when a wreck is stranded near the shore, and in some cases the two beaches connecting the rock with the shore enclose a lake between them, as in the case of the Lake of Manarre, off the south coast of France, near Toulon.

The influence of vegetation upon coast erosion must also be taken into account, both as assisting erosion and accumulation. The assistance given by the long ribbons of the "Laminaria digitata" seaweed in transporting boulders along the sea bottom has been pointed out by Mr. G. H. Kinahan,* who found boulders having such weeds attached thrown up upon the beach on the Galway coast, after storms, some of the fronds of these weeds being 20 feet long. I have myself seen tons of weed-attached boulders thrown up upon the shore after storms upon the south coast of Ireland.

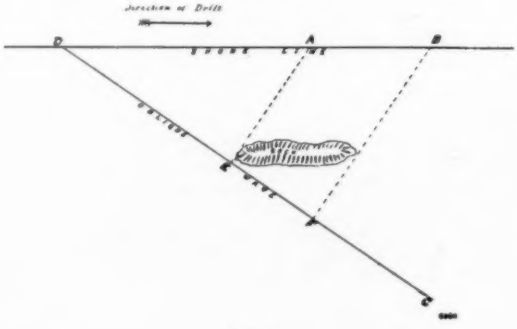


FIG. 4

Vegetable growths, however, sometimes give protection and encourage deposition of silt;† this is notably so in the case of the Mangrove and Courida in tropical countries, especially thelatter, which greatly facilitates the growth of deltas,

* Procs. Roy. Irish Ac. 2nd Ser. Vol. iii., p. 202.

† Dr. Cornish on "Sea Beach and Sandbanks."

etc., by the deflection of the water by their roots into numerous little streams which interfere with each other. Dr. Cornish says:—"Such growths appear to be unknown beyond the tropics; nevertheless, this mode of protection from sea attack might afford scope for interesting experiment in colder climates."

Bent or marram grass is well known as a protection against wind drift of sand dunes; being very wiry and flexible, this grass bends down before the wind, and, lying down along the surface of the sand, affords excellent protection from the wind.

We now pass on to the consideration of certain artificial structures on the foreshore as affecting the action of the various forces at work. Piers or jetties projecting into deep water have practically the same effect as headlands and promontories in checking the littoral drift, and causing accumulation on one side with scour on the other. It is well known how the sand often follows out piers which are built with the purpose of reaching deep water, and continually defeats that purpose, until in many cases the work has had to be abandoned as hopeless, owing to the huge accumulation of sand produced; and even if the pier can be run out to deep water without an overwhelming accumulation resulting, it is almost invariably the case that, if the shore adjoining is a sandy one, a troublesome bar is formed by the escaping drift round the end of the pier, requiring constant dredging or the use of scouring basins and sluices.

With high and low groynes, the result is also a checking of the along-shore drift, which, in the case of high groynes, often amounts to a serious danger instead of a protection, owing to the great scour which takes place to the lee of such structures. Low groynes, while still checking the drift, allow of a certain escape of sand, etc., over the top, so that there is not the same dangerous scour on the lee side. This difference constitutes one of the great advantages which low groynes possess over high, combined with the fact that a much lighter and less costly construction is required, owing to the smaller amount of surface exposed to the sea.

The attrition of the particles of shingle, sand, etc., is another important factor in causing erosion. These are rolled about and dashed together as well as against the foreshore and cliffs, having a powerful degrading action, both on each other and upon the cliffs and foreshore. In heavy storms great boulders and fragments of rock are broken off and hurled against the parent rock like battering rams, thus lending themselves to the general work of destruction. Another curious effect is that of water contained in cavities and fissures of the rocks; when struck by a heavy wave, the blow of the wave is transmitted with a bursting effect to the surrounding rock. The same applies to air, when imprisoned under suitable circumstances, only in this case the blow of the wave is converted into an explosive effect, blowing up promenades and sea walls. Sea walls are often a source of great trouble on the foreshore; the waves, striking the face of a vertical or nearly vertical wall, when in the act of breaking, project great volumes of water skywards, which, falling at the toe of the wall, dredge out the material from in front of the foundation, and often cause a collapse. Fig. 3 shows such a wave breaking against a wall, a glance at which will show the enormous scouring effect which must take place on the fall of the water. Even without this actual projection the back wash of a wave from a curved smooth surface has a powerful scouring action, to get over which difficulty "stepped" walls were designed. This is undoubtedly the best design for a wall to afford protection to a coast; but they are very expensive to build, owing to the distribution of the materials of construction not being economical.

The supply of the material which composes the foreshore is also another point to be considered. We are not dealing with an unlimited supply, but a strictly limited one. Far the largest proportion

of sand and shingle which we see on the shore is simply in "circulation," suffering some loss owing to attrition of the particles, and some gain owing to the degradation of the land. But, speaking generally, if we get a great accumulation in one place. it is safe to infer a corresponding loss at some other point or points of the coast.

It appears probable that the gain from erosion of cliffs, etc., just about balances the loss due to attrition. There is a further loss, however, which remains to be dealt with, and that is the sweeping out to sea by rivers and tidal currents of great quantities of sand, etc., to form shoals, bars, etc., etc. Whether this is balanced by a corresponding influx from the sea bed, due to some other cause, is very doubtful.

The size of the grain, the shape, and specific gravity of the particles composing a foreshore greatly influence their behaviour. The lighter particles, such as mud, remaining for a long time in suspension in the water and obeying the slightest current, sand is also stirred up into suspension by waves and eddies, and thus will also obey the currents. It is, therefore, in the case of shingle and the larger fragments and boulders that we may look for the most erratic behaviour, since they are not so easily shifted by current action, and always travel along the surface of the sea bed instead of in suspension in the water.

Mud and fine silt, when stirred up in the water, travels with it, following almost exactly the stream lines taken by the water. It swirls round and eddies with the water without much tendency to be thrown out of the eddies by centrifugal force. Sand, on the other hand, has a strong tendency to be thrown out of any particular eddy it may be revolving in, owing to its greater interia; or, if the stream lines of the water are deflected, there is a tendency for the sand to suffer a *slighter* deflection, and so be thrown out of the current sometimes.

It may be taken as a general rule that, as we go seaward, the particles moved by the water become smaller and smaller, the larger ones dropping to the bottom, if in suspension, nearer to the coast than the smaller ones, owing to the agitation becoming less and less on the bottom as the water increases in depth; the same cause prevents shingle and larger stones being moved far from the coast-line. We thus get a natural selection in the size of the particles, and a preliminary rough grading into shingle, sand, and mud.

The mud, it is generally understood, travels seawards, as there is no chance for deposition in the disturbed water near the land, so that it simply moves about this way and that, always in suspension, until some chance current brings it out beyond the region of wave action. Hence it is that the silt found in the depths of the ocean is of the finest description. There is, naturally, a great area of deposition beyond the edge of the "Continental Platform." Sand, on the other hand, is deposited in shallower water, producing shoals and sand-banks, which interfere with navigation; and the shingle is only to be found where the agitation of the water is most intense.

It appears that, when sand enters a current which is subjected to comparatively simple changes of direction, or eddies, that the above-described peculiarity of travelling in curves having a larger radius than the curves followed by the water which carries it, throws the sand out of the current, perhaps to form a sand-bank at the deflection of a tidal current, or in the eddy at the lee of a pier or promontory. If, however, the current has produced in it a very complicated set of eddies, such as would be caused by a rough boulder-strewn bottom, the particles of sand flung out from one swirl are picked up by another, and deposition is prevented.

There is a sort of automatic protection given by the sea against itself in the following way:—When a cliff composed of clay, sand, stones, etc., is being eroded and pulled down by the sea, the first action of the water upon the fallen masses is to sort out the finer particles of sand and clay, and to wash them away, leaving

behind the larger pieces of stone and gravel; these are then often driven by the waves up into a regular bank along the toe of the cliff, so giving it a certain amount of protection.

The different behaviour of the different-sized particles makes it possible for the sea to be accumulating shingle and coarse stones in a certain place, and at the same time removing from that place the sand and finer matter. In fact, the conditions suitable for the accumulation of the one are seldom those which are suitable for the other. The following instance will explain my meaning:—We will assume that the sea has thrown up a bank of shingle having a comparatively steep gradient, because the particles of shingle being difficult for the water to move, a steep gradient is built up before gravity gives the necessary assistance to the "back-wash" of the waves and places it on a par, in regard to transporting power, with the "up-rush," assisted by the violent shoreward impact of the "plunge." When this gradient is developed, the amount of shingle brought up by each wave is equal to that brought down by its "back-wash." Now, suppose we throw a handful of sand upon the slope; the result will be, assuming it does not sink through the interstices, that it will be swept up by the "up-rush" and down again by the "back-wash," because, owing to the ease with which it is shifted by the water, the steep gradient places the "back-wash" of the waves at too great an advantage. It will be clear, therefore, that for the sand to resist being torn down again, the slope would have to be much flatter; and until the requisite flatness is reached, on all intermediate grades the sand would travel seaward and the shingle landward, on the whole.

I may mention here what, I think, is an explanation of the gradually *increasing* gradient landward, found on all shingle banks when waves of uniform size act on them for some time. The tendency, as shown above, is to establish such a gradient seaward as will give the necessary assistance to the "back-wash" to make its transporting power equal to that of the up-rush. Now, since the water starting down the slope has at first no velocity, and then gradually develops it in accordance with the formula $v^2 = 2gh$ (h being the height fallen through). In order for this velocity to shift the shingle, it is necessary that the gradient should at first be very steep and gradually become flatter as the velocity grows, so that the transporting power of the velocity + the help of the gradient would be = a constant. Percolation, no doubt, comes in to explain this, too; but it is not, in my opinion, sufficient.

In these articles I have not attempted to go into the best method of sea-defence, but rather to indicate some of the more important considerations which must be taken into account. I would, however, lay special stress upon one point: that only a complete and careful investigation of the peculiar factors involved in each individual case of erosion can give any indication of the best method to be adopted for protection. I am indebted to the kindness of Mr. J. C. Inglis, of the Great Western Railway Company, for the photographs Nos. 1 and 2 in this article.

On Some Conditions Governing the Production of Iron and Steel Castings.

By PERCY LONGMUIR.

II.

Blowholes, when present in grey iron castings, are rarely due to the liberation of gases occluded during the molten state, for the high content of silicon and manganese tend to retain these gases dissolved in the metal. In far the greater number of cases, blowholes are due to the condition of the mould or the method of pouring. In green sand moulding, particularly, a hard or a too damp mould is morally certain to blow. This applies equally to the mould as a whole, or to parts of it; local hard or wet spots giving the same effect. Such a case is illustrated in Fig. 11, where it will be noted that the upper portion of the fracture is honeycombed with blowholes, the bottom portion being comparatively solid. Here sufficient moisture has been present to cause bubbling from the bottom, the gas bubbles and shots of metal having risen to the top, where escape has been retarded by a solid outer crust. As a final result, the bottom of the casting where the disturbance originated is solid and free from blowholes. This wet spot, typified in Fig. 11, represents excessive dampness in one portion of the mould, and not *wet* in a literal sense of the word. Naturally, had the mould been actually wet, the fluid metal would have been violently ejected by the sudden generation of steam. However, sufficient moisture was present to cause the effect noted.

Local hard spots in the mould have a very similar effect, except that the disturbance is due to the non-escape of gases of the mould and not to the formation of steam. Further, this disturbance may detach a portion of the sand, forming on the casting a "scab"; and in such an event blowholes are not very likely to form, for the gases, by removing the hard spot, find a path to freedom. Although blowholes may not be present, dirt represented by the detached sand will be found along the top of the casting—an evil which, in conjunction with the scabs on the lower face, may be quite equal in effect to the presence of blowholes. The latter will be caused just as readily by a hard as a wet mould, the difference being that the former may give rise to scabs more readily than the latter.

Apart from the condition of the sand of mould or core, blowholes may originate from the presence of other metals—as, for instance, chaplets—in the mould. Fig. 12 shows an actual though somewhat unusual type of such a blowhole. In this instance it will be noted that a screw has been cast in by leaving the head projecting, and this head must have been either damp or rusty, hence the blowhole. Similarly, any metal forming part of a mould—for example, chills, spindles, rods, etc.—will, unless free from rust and moisture, give rise to blowholes. The practice of casting liners on a steel or iron shaft concerns the brass-founder rather than the iron-founder; but, quite irrespective of the metal or alloy employed, the metallic core must not only be free from rust, but also perfectly dry. Rust or scale, quite apart from preventing metallic contact, will give rise, under certain conditions, to the formation of gas which, trapped within the metal, results in blowholes. The practice of warming a metallic core or chill is, therefore, good, and in a dry sand mould practically always leads to success. With a green sand mould the introduction of the warm core or chill must be followed by casting, otherwise moisture will condense and unsoundness result.

Practically, then, blowholes in grey

iron castings are caused, in the majority of cases by (*a*) the formation of steam, or (*b*) the impervious nature of part or the whole of the mould to the passage of gases generated in the mould during casting. Obviously, remedies are to be found by attention to the mould rather than the metal—a statement supported by the fact that the majority of these blowholes show oxidation tints. It is hardly necessary to add that any gases absorbed during melting and liberated on solidification would give blowholes free from any oxidation film.

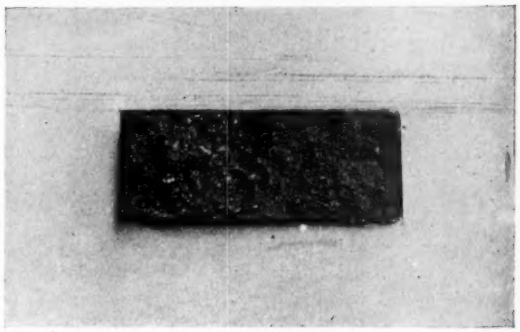


FIG. 11.—FRACTURE SHOWING BLOWHOLE.

Further Treatment of Grey Cast Iron.—Castings of grey iron do not readily lend themselves to after treatment, and the only control offered is that of regulating cooling in the mould; practically, this treatment is summed up in the one term "chilling." Generally, chilling is followed in order to obtain a white and consequently hard surface, as in the production of chill rolls, car wheels, and so forth. Quite apart from this general application, in which the chief requisite is a hard wearing surface, chilling may be practised in order to (*a*) equalize the rate of cooling in castings of unequal bulk, or (*b*) to secure as near an approach as possible to a machined face. Groups (*a*) and (*b*) are, however, comparatively unexplored, and definite information is not available. With regard to equal cooling, if, in casting, the change from heavy to light section is abrupt, then the application of a chill to the heavy part may minimize "draws" or contraction strains at the junction. With certain intricate castings this method has proved successful; but, as is readily apparent, its disadvantages in the cost of metallic chills and the hardness induced, prevent a general application. The converse of this method lies in keeping the thin part of the casting hot; as an example, the following method—at one time followed—may be quoted:—On casting a pulley with heavy arms and light rim, immediately on solidification the top half of the moulding box was removed, and a trench dug out round and separted from the rim by a 2-in. wall of sand, care being taken not to expose the rim. This trench, filled with molten metal, acted as a heat reservoir to the thin walls of the rim, and to some extent produced more nearly uniform cooling conditions. Other examples will readily occur, as, for instance, exposing a heavy part of the casting and allowing air to play on it whilst the lighter parts remain covered by sand. The sand round a heavy boss may, on completion of "feeding," be removed and water sprinkled on the boss; for instance, the boss core of a heavy flywheel may be dug out and water used as above, and

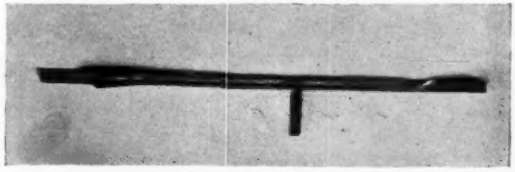


FIG. 12.—BLOWHOLE.

this method will often prevent contraction strains developing at the junction of boss and arm. A wider application lies in the circulation of water through the core of a heavy casting, as followed in the days of cast iron ordnance. Such a method, if applicable to ordinary castings, has many advantages, chief of them being that the water never comes into actual contact with the metal, which, in the case of cast iron, is of some importance. Further, approximately equal rates of cooling may be obtained, resulting in not only diminished contraction strains, but also in a more uniform metal. Whilst the circulation of water around or through the heavy parts of a casting has advantages, the actual application of water should only be adopted as a last resort to save a hopelessly-designed casting. Types of such castings are by no means unfamiliar in many foundries. Whilst the properties of certain brasses and bronzes are improved by water-cooling, such treatment in the case of cast iron is, owing to the sensitivity of iron and carbon, at high temperatures, not advisable, except in the direction indicated.

Group (*b*)—the application of chills to secure a smooth face—has certain possibilities worthy of more study than the subject has received, but a limit of applicability is found in the hardness induced. Ignoring for the moment this limitation, the substitution of a turned steel* core for one of sand will be found to give a truly cylindrical and smooth hole. Internal parts of castings difficult to reach by tools may be given a smooth face by ramming a chill of the requisite contour in the sand core—a method also advantageous in the case of internal portions which have hard wear to withstand. In certain cases, chills have been app'ied to form the seat of valve bodies with fair success. Finally, in summarizing this section, it may be noted that although chilling is a comparatively uninvestigated matter, its application has many possibilities, quite apart from the regular line of chilled products. Chills can be readily applied to any part of a casting by ramming up with the mould or core; and whilst the excessive hardness may in some cases prove a drawback, in others it may be an actual advantage, and in a few, possibly, of no moment. This hardness is confined to the vicinity of the chill, and is greater the lower the silicon content of the cupola mixture.

Heat Treatment of Grey Iron.—Occasionally a casting may turn out harder than intended; in such a case the difficulty of planing or turning may be reduced by annealing, *i.e.*, heating to a full bright red, followed by slow cooling. Grey iron castings are not, as a rule, so treated, neither is the method recommended; but still it will not be profitless to examine briefly the change which takes place. Excessive hardness, as already shown, is due to the presence of structurally free cementite, which in turn may be due either to rapid cooling or to insufficient silicon in the charge.

This free cementite is extremely sensitive to heat treatment, which, if followed by slow cooling results in a dissociation of the compound into its constituents of ferrite and carbon. Any softening as a result of annealing is due entirely to this decomposition of the hard cementite into iron and free carbon, the latter being distinguished from graphite only by its non-crystalline character. Although the requisite degree of softness is secured, this gain is at the expense of other properties, as illustrated in the following:—

GREY CAST IRON. 1·8 per cent. Silicon.

	Max. Stress. Tons. per sq. in.
As cast	11·9
Annealed in a non-oxidizing atmosphere	6·8

Other similar results could be quoted. These are, however, sufficiently convincing. The writer's experiments on the heat treatment of grey iron lead to the conclusion that, with graphite at or over

* Metallic cores are coated with p'umbago or oil. If cast iron cores are used the expansion due to repeated heating must be remembered when holes of exact size are required. All internal chills should be given a slight taper and removed from the casting before contraction is complete.

2.5 per cent., the only gain is that of softness. Under these conditions, this gain is associated with a loss of strength, as judged by tensile tests, and an increase in porosity as judged by water and steam trials.

Heat Treatment of White Cast Iron.—From the foregoing it will be evident that successful heat treatment can only be applied to cast irons containing the minimum amount of graphite. Thus, with the familiar malleable cast iron the first product is always a white iron. These hard castings are softened by annealing, a process which also increases very considerably their tensile strength.

Mixtures for malleable should be such as will yield in the resulting castings a white iron throughout, and not one showing a grey centre. Obviously, the silicon content should be sufficiently low in order to retard a precipitation of graphite. Actually, the permissible range varies according to the thickness of the castings, from 0.6 to 1.5 per cent. silicon. The latter content applies to very thin castings only, which are chilled by the act of casting. The higher the content of silicon the sounder the castings, for in white iron blowholes due to occluded gases may occur in addition to those enumerated under the heading of grey iron. Hence it is policy to run the silicon of the mixture as high as is consistent with the production of white castings. Manganese, as already noted, favours the combination of iron with carbon; but in the presence of manganese the carbide so formed is exceedingly difficult to split up into iron and carbon. Hence, in practice manganese should be low, 0.2 per cent. forming a suitable limit. The relation of other constitutents are shown in the following analyses:—

MALLEABLE CAST IRON.

	I.	II.	
*Graphite ..	2·08	0.36	Average
Combined carbon	0.12	0·73	drillings.
Silicon	0·72	0·78	
Manganese ..	0·30	0·09	
Sulphur	0·06	0·30	
Phosphorus ..	0·13	0·07	

*Chemical analysis does not distinguish amorphous carbon from graphite.

No. I represents a ... American malleable cast iron forwarded to the writer for examination, whilst No. II is a typical British product. It will be noted that the total carbon of No. II is lower than that of No. I, and, further, that the sulphur content of No. II is five times as great as that of No. I.

This difference in total carbon distinguishes between two methods of annealing: No. I, in which the chief object is to change the condition of the carbon, and No. II, in which not only is the condition of the carbon changed, but a partial decarbonization is also effected. Nos. I and II represent American and European practice respectively.

In considering the heat treatment of grey iron, it was shown that the efficiency of the softening depended entirely on the dissociation of the hard cementite into ferrite and free carbon. A white iron similarly treated will yield a "black heart" casting, so termed owing to the fracture showing a dark centre with light edges. Such a casting represents annealing conditions in which no carbon removal is attempted. This process consists essentially in heating the castings to a temperature of about 850 deg. C., maintaining the heat for a period of from two to five days, and then slowly cooling to 600 deg. C. Structurally, the product is built up of ferrite, pearlite, and amorphous carbon. No free cementite is present, consequently the material is soft to tool; it also has a fair tensile strength with some elongation. The following tests are of commercial castings annealed in the foregoing manner:—

Max. Stress. Tons per sq. in.	Elongation per cent. on 2 ins.
11·5	3·0
16·8	2.0 on 6 ins.
20.5	4·7
25·3	4·0

Annealing which has for its object a partial decarbonization is effected in an oxidizing atmosphere, which may be obtained by packing the castings in iron ore, mill scale, or other oxidizing material. The carbon is removed comparatively

FIG. 13.—UNANNEALED WHITE IRON;
MAX. STRESS 15·9 TONS PER SQ. IN.

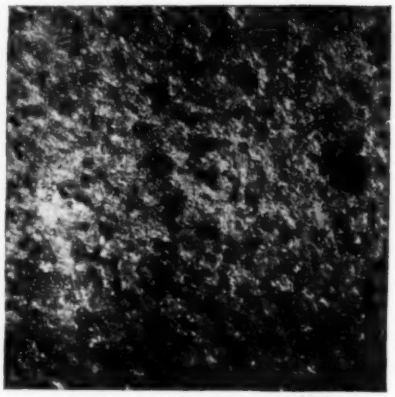


FIG. 14.—ANNEALED;
MAX. STRESS. 29·2 TONS PER SQ. IN.

slowly, hence the annealing time is long and varies from five to ten days, according to the thickness of the castings. Naturally, the rate of removal is greater the higher the temperature, but a limit is found at from 800 deg. to 900 deg. C., owing to the danger of deforming the castings. The carbon remaining is not uniformly distributed, but is lowest at the outer edge, and increases progressively towards the centre, where a maximum is reached.

As in the former case, the castings are structurally built up of ferrite, pearlite, and amorphous carbon. Thus, a section of a round bar would show an external ring of oxidized iron, an inner ring of siliceous ferrite; from thence, inwards, ferrite decreases, whilst pearlite and amorphous carbon increase to the centre. Figs. 13 and 14 illustrate the structural change induced by annealing, and the tensile tests given below each figure illustrate the gain in mechanical properties.

Malleable castings have received attention from the technical press, consequently the foregoing notes on annealing are contracted; however, some reference is essential in order to indicate clearly the two following features. Of these, the first is that of the influence of sulphur. Reference has already been made to the difference in sulphur contents of American and British malleable castings. As a general rule, American practice regards 0.1 per cent. as a danger limit, whilst the average is found at about 0.05 per cent. On the other hand, the average sulphur content in British practice is about 0.3 per cent.; indeed, the writer has examined castings containing up to 0.4 per cent.*, possessing very fair mechanical properties. Examination of the following tests will support this statement:—

Analysis, excluding carbon.		Max. stress. Ton per sq. in.	Elongation % on 2 ins.
Silicon ..	0·70	24·4	1·7
Manganese ..	0·14	27·0	5·7
Sulphur ..	0.39	24·0	3·5
Phosphorus ..	0·05		

This amount of sulphur associated with so low a manganese would be dangerous in a grey iron casting, whilst in a steel casting it would be absolutely fatal. Yet the foregoing tests are good, and the middle one especially so. It may also be added that each result reported represents the mean of two tests in close agreement.

American practice favours a "short anneal"; the annealing time in British

* Representing metal melted in a cupola.

practice is usually much longer. This prolonged annealing destroys the meshwork form of the iron sulphide by gathering it together in a globular form. Translated into the solid, it will be seen that these globules do not destroy the continuity of the mass. Herein lies one advantage of the "long anneal," an advantage of undoubted merit; nevertheless, ignoring sulphur, questions do arise as to whether the annealing time cannot be considerably shortened. Royston and Ledebur have experimented in this direction; the former showed in 1897* that by heating a white iron to the temperature at which, on cooling, it would solidify, a "black heart" product resulted.

The writer has conducted various experiments on this form of heat treatment, of which the following may be quoted:—

ANALYSIS OF UNTREATED CASTINGS.

Combined Carbon.	Graphite.	Silicon.	Manganese.	Sulphur.	Phosphorus.
3·40	—	0·39	0·05	0·02	0·02

This metal, as cast, yielded an average tenacity of 12.9 tons per square inch. The following results represent averages obtained from the same metal in the condition of annealed and heat-treated:—

ANNEALED.
Time = 100 hours.

Combined Carbon.	Graphite.	Tons per sq. in. Max. stress.	Elongation % on 2 sq. ins.
Varied from 0 at the edge to 0·5 % in the centre.	Varied from 0 at the edge to 3·2 % in the centre.	25·4	2·1

HEATED TO ABOVE 1,000° C.
Time = 4 hours.

Combined Carbon.	Graphite.	Max. Stress. Tons per sq. in.	Elongation % on 2 ins.
0·77	2·57	21·4	None.

The annealed castings represent normal works practice, and the results given are the mean of three tests. The second group represents the following experimental conditions:—The castings were laid on the floor of a coke-fired muffle at a dull red heat; the temperature quickly raised to a white heat, and then allowed to fall, the castings being drawn on reaching a dull red heat. Under these conditions, scaling, *i.e.*, superficial oxidation, occurred, but no evidence was shown of internal oxidation. The whole of the free cementite was split up into ferrite and amorphous carbon, and in conse-

* Journal of the Iron and Steel Institute, No. 1, 1897.

FIG. 15.—STEEL AS CAST.

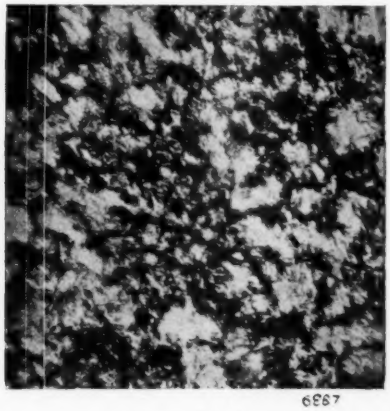


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FIG. 16.—STEEL ANNEALED.

quence the product was soft and easily machinable. As will be seen, the tensile strength has risen from 12.9 to 21.4 tons per square inch, and is only some 4 tons per square inch below that of the normal malleable product. Although soft in the sense of machining, no elongation occurred, and the shock-resisting qualities have not yet been examined. However, these results, which have been repeated several times, show the process to be one worthy of further investigation, for it has in it much of practical value.

Steel Castings.

In only exceptional cases does the carbon content of these castings exceed 0.5 per cent., and is generally nearer 0.35 per cent. Within limits, the higher the carbon content the greater the tenacity; but as the majority of specifications lay stress on ductility, tenacity alone is useless. Usually an elongation of from 15 to 20 per cent. on 2 in., and a bending angle of 90 deg., is specified, and failure to meet these items is the cause of more rejections than that of failing in tensile strength. A serviceable composition for average specification work is as follows: Carbon, 0.3 per cent.; manganese, 0.8 to 1.0 per cent.; silicon, 0.2 per cent.; with sulphur and phosphorus as much below 0.08 per cent. as possible. A glance at the following table illustrates some of these features:—

Analysis.					Max. stress, Tons per sq. in.	Elongation % on 2 in.
Carbon.	Silicon.	Manganese.	Sulphur.	Phosphorus.		
0·29	0·07	0·16	0·07	0·06	23·7	10·0
0·29	0·14	0·92	0·06	0·02	30·9	7·5
0·20	0·04	0·38	0·15	0·06	18·2	4·1

These steels are all in the cast condition, and the influence of manganese in raising the maximum stress without seriously decreasing the elongation will be noted. The third steel gives, for its carbon content, a low elongation; and even after annealing under the best possible conditions the elongation could not be made to exceed 10 per cent. Sulphur here has a vastly different effect to that noted in malleable cast iron.

Annealing.—The success of any steel casting is very largely determined by the annealing given, and successful annealing involves both time and temperature. The structural change induced by annealing is shown in Figs. 15 and 16, and it will be noted that the sharp demarcation between ferrite and pearlite in the steel as cast is destroyed in the annealed material, and these constituents tend to merge one into the other. The influence of this change on the mechanical properties is shown in Fig. 17. A vast amount of research has been devoted to the heat treatment of steel and the discovery has been made that when working on small samples of forged material, the

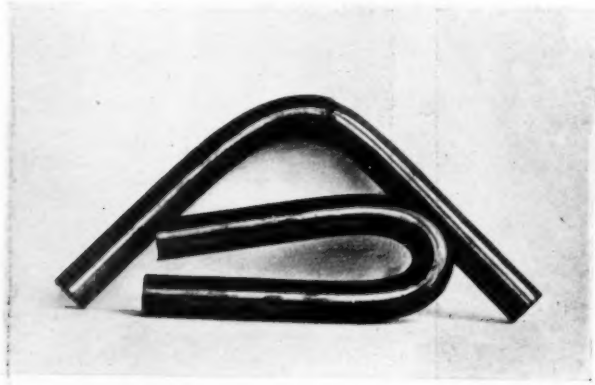

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FIG. 17.—THE MECHANICAL VALUE OF ANNEALING.

structural change shown in Figs. 15 and 16 can be obtained in a comparatively short time. These results are not directly applicable to castings for the following reasons:—The structure of steel as cast has no relation to that of forged steel; results obtained from small sections are not applicable to castings in which mass forms one element, and the object of annealing steel castings is twofold, the chief one being to relieve internal contraction strains. Evidently, then, cooling in the case of intricate castings must be slow.

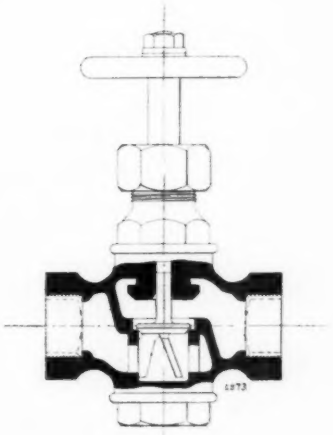
For castings containing from 0.3 to 0.5 per cent. carbon, a suitable annealing temperature is found between 900 deg. and 950 deg. C., and a suitable time at this temperature is represented by three days (72 hours). The slower the cooling down from this temperature the better the elongations and bending angles of the products. The castings themselves are freer from internal strains, and less liable to sudden fracture under shock. The following results are obtained from test bars *cast on* commercial castings annealed in the foregoing manner:—

Content of Carbon.	Max. Stress. Tons per sq. in.	Elongation % on 2 ins.	Reduction of area %.
0·28	28·0	33·5	45·6
0·29	27·2	24·0	32·3
0·51	35·4	22·5	27·3

These results, obtained from cast annealed material, are almost equal to forged steel, save in the one property of resistance offered to shock.

Combined Steam Stop and Check Valve.

THE valve illustrated in the accompanying figure is specially adapted for use on the delivery pipe of injectors or pumps for feeding against boiler pressure. The particular feature of the design is that, should any grit or dirt get on the seat of the check valve when steam pressure is up, by closing down the valve with the wheel and uncoupling the bottom hexagon nut the check box and its cage are released from the fitting, and the valve can then be ground in and replaced. On again opening the steam valve, the fitting is in working order. It is made by Messrs. Madan & Co., Ltd., Manchester.



ENGINEERING PROGRESS

RAILWAYS.

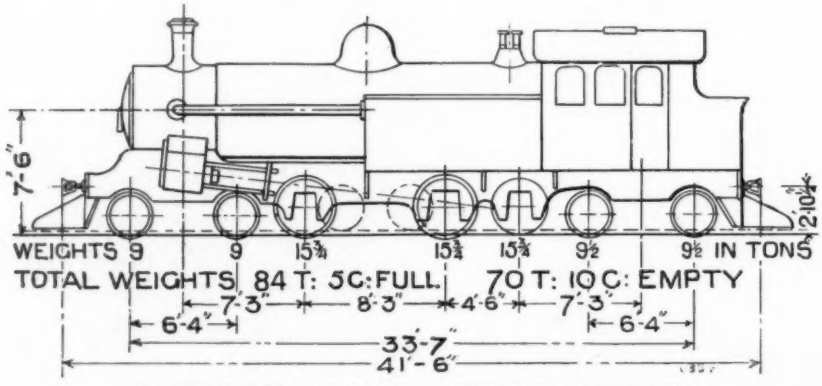
Rack and Adhesion Locomotive for the Central South African Railways.

F. C. COLEMAN.

SOME few months ago, the Vulcan Foundry, Limited, of Newton-le-Willows, Lancashire, delivered a number of large "Pacific"-type locomotives and several double-end tank locomotives for service on the Central South African Railways, and have, in addition, within the last few weeks completed, for the same railway system, some very powerful rack and adhesion engines, which have been primarily designed for the purpose of assisting the heavy corridor express trains over the 1 in 20 incline encountered between Waterval Onder and Waterval Boven, on the Pretoria-Laurenço Marques section of the Central South African system.

These locomotives, a photograph and diagram drawing of one of which we are enabled to reproduce herewith, weigh—in working order—no less than 84½ tons, and are the heaviest and most powerful rack engines ever built. The specifications required that the engines should be able to assist, with the aid of an adhesion engine in front, a train of a minimum load of 350 tons over a 1 in 20 gradient, which continues for about 3½ miles, and that they should condense their exhaust steam while passing through a tunnel near the top of the incline, so that it will readily be seen that a combination of high tractive force, steaming capacity and brake power was called for, and these requirements the builders appear to have amply met.

The engines have two entirely distinct pairs of cylinders, 18 in. in diameter by 20 in. stroke, the inner pair of which drives a coupled pair of cog wheels, carried upon a frame suspended from the leading and driving coupled axles. The connecting rods of the inside engine are connected to projections of the coupling rods of the rack gear, and not directly to the crank pins, an arrangement which has been necessitated by the restricted width available between the tyres. The rack axle bearings are adjustable vertically so as to compensate for the wear of the adhesion wheel tyres, and for this reason also the teeth are of involute form, so as to ensure correct action between adjustments. The cranks

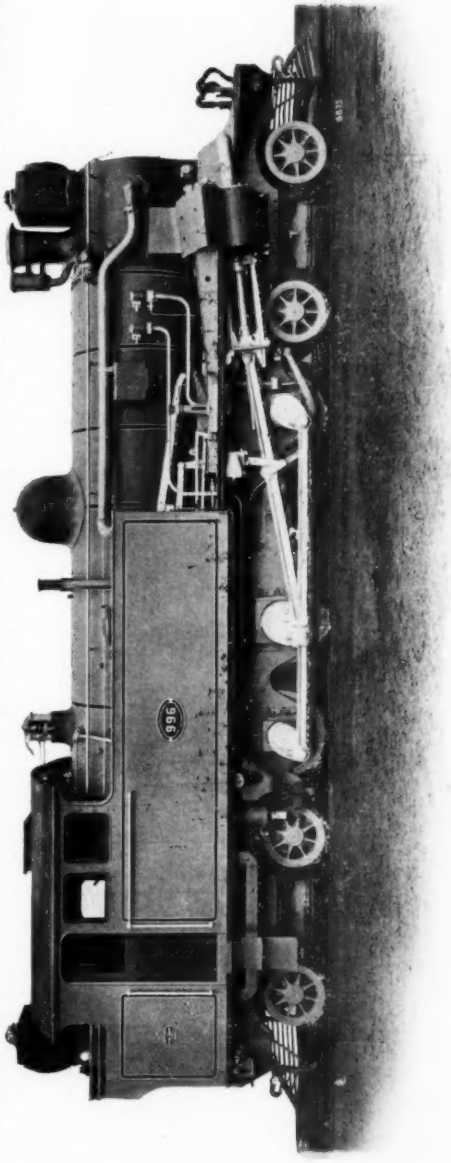


RACK AND ADHESION LOCOMOTIVE FOR THE CENTRAL SOUTH AFRICAN RAILWAYS.

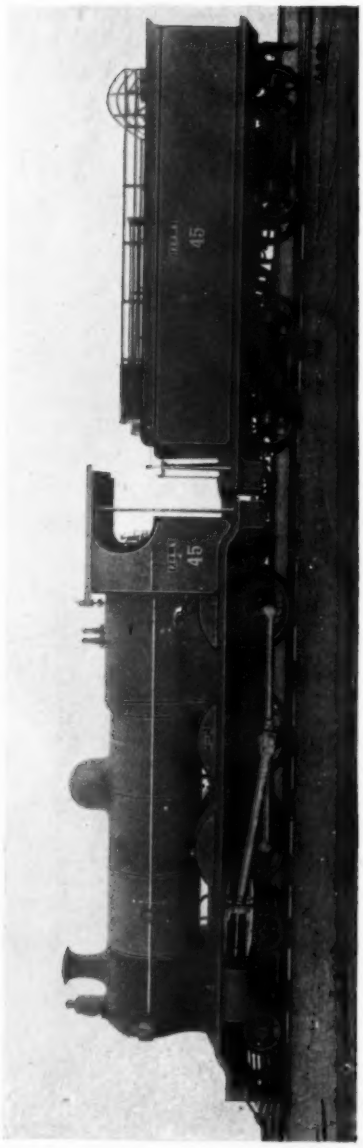
are of the disc type, having triangular circumferential grooves in which the cast iron blocks, of a hand power band brake, work. The teeth of the rack driving wheels are cut from steel rings and driven through spring keys from the axles so as to compensate for slight irregularities in the pitch of the rack. The six coupled wheels driven by the outside cylinders are 3 ft. 6 in. in diameter, and carry a load of 45 tons. The valve motion is Joy's, and that of each engine is separately reversed by its own screw gear. There are also two independent regulators. There are no fewer than five distinct brakes: (1) The steam brake on all the coupled wheels and on both bogies; (2) the hand brake on the coupled wheels; (3) the hand-worked band brake on the crank discs of the rack engine; (4) the le Chatelier counter pressure brake on the pistons of the adhesion engines; and (5) the counter pressure air brake on the pistons of the rack engine. This last-named brake comprises a valve in the base of the blast pipe, which isolates the cylinders from the smoke-box and prevents the entrance of hot gases and cinders when the motion is reversed, whilst there is also a pair of non-return valves, through which air is drawn from outside the smoke-box into the exhaust ports and thence compressed into the steam pipe. In addition there is fitted a graduating discharge valve through which the compressed air is allowed to escape into the atmosphere through a silencer carried on the chimney, and a small water jet delivers a cold spray into the exhaust space, which serves to take up the heat of compression and prevents overheating of the cylinders.

In addition to the engine brakes, these locomotives are equipped with a combination ejector and pipes for working the vacuum brakes of the train, if required.

The boiler is built of mild steel plates with a copper firebox, and is worked at 200 lb. per sq. in. with a very large water capacity in order to assist the supply of steam through the short tunnel where the blast pipes are not working. There are 197 charcoal and iron tubes, 2 in. outside diameter and 12 ft. 7 in. in length between the tube plates. The heating surface amounts to 1,438·33 sq. ft., to which the tubes contribute 1,298·13 sq. ft. and the firebox the remaining 140·2 sq. ft., the grate area being 33·5 sq. ft. The combined capacity of the side and bunker tanks is 1,200 gallons, and there is coal space for 50 cwt. of coal. Two injectors and two feed pumps are fitted, and the tanks can be rapidly



RACK AND ADHESION LOCOMOTIVE FOR THE CENTRAL SOUTH AFRICAN RAILWAYS



4-6-0 TYPE METRE-GAUGE LOCOMOTIVE FOR SOUTH AMERICA.

emptied, after each trip, through a large discharge valve. The condensing gear is arranged to circulate the water in the side tanks and is practically silent in working. These rack and adhesion engines weigh, when empty, 70½ tons—and, in running order, 84½ tons—and in appearence conform to the other types of powerful locomotives of the Central South African Railway system, built by the Vulcan Foundry, Limited.

4-6-0 Type Locomotive for South America.

THE accompanying illustration is that of an engine lately built for a metre-gauge line in South America, the complete design of which was carried out by the firm of A. Borsig, Berlin, and the whole of the raw material with the exception of the copper-plates, rods and boiler tubes, being made at the firm's Silesia works.

The engine is of the six-coupled bogie type and has an eight-wheeled tender. Although built for a metre-gauge it is a powerful machine, capable of doing heavy work and of running at a high speed, while the large quantities of fuel and water carried allow it to run over long distances without replenishing the supplies.

The cylinders have a diameter of 17 in., and a stroke of 24 in., and lie outside the frames. The motion is of the Stephenson type driving piston valves without the intervention of the usual rocker-shaft, the valve-casings lying between the frames. By this means the steam pipes are kept short, and the exhaust is as straight as possible. The reversing gear has a hand-wheel and screw, and is fitted on the right hand side of the cab. The connecting rods are, owing to the arrangement of the wheels, necessarily long and to keep down the weight both they and the coupling rods are milled to a channel section. The driving-wheel tyres are without a flange.

The boiler has a Belpaire firebox, and the grate is especially adapted for burning the "Quebracho" wood used instead of coal. The safety valves are of the Pop type, while an unusually large and deep-toned whistle is employed which can be heard long distances.

The tender bogies are built on American lines. The tank has a large fence to allow of storing as much as 350 cub. ft. of wood.

Both engine and tender are fitted with the auto-vacuum brake. The engine has also combination ejectors, acetylene head

lights, steam sanding gear and the timber cow-catcher common on Argentine narrow-gauge lines.

The trials made on putting the engines to work proved them to have most satisfactory hauling power, while at the speed of forty five miles per hour they run quite steadily. The leading dimensions are as under:—

Locomotive:—	
Diameter of cylinders	17 in.
Stroke of pistons	24 in.
Diameter of driving wheels ..	4 ft. 5½ in.
Diameter of bogie wheels ..	2 ft. 5½ in.
Working pressure..	170 lb.
Heating surface	1,320 sq. ft.
Grate area	16 sq. ft.
Weight empty	36 tons
Weight in working order ..	41 tons
Tender:—	
Tank capacity	3,300 gal.
Fuel space	350 cub. ft.
Weight empty	12 tons
Weight in working order.. ..	32 tons

The Reconstruction of the Moncreiffe Tunnel.*

D. McLellan, M.Inst.C.E.

This tunnel, which is on the Caledonian Railway, near Perth, is 1,218 yards in length, of which, before reconstruction, 842 yards were lined with brickwork and 376 yards were unlined, The reconstruction was necessitated by the deterioration of the brickwork of the lined portions since the tunnel was built in 1848, and the disintegration of the rock at some of the unlined portions, resulting in pieces falling on to the rails.

The reconstructed tunnel has 1,083 yards lined with brickwork, the remaining 135 yards being unlined. Advantage has also been taken of the reconstruction to enlarge the internal section of the tunnel, and to raise the rails so as to give room for more ballast between the bottom of the sleepers and the rock formation. The new section has vertical side walls and a segmental arch, and admits of the passage of the largest west-coast joint stock with open doors. The minimum thickness of the side walls is 9 in., and that of the arch 18 in. the average thicknesses being 1·66 ft. and 2·06 ft. respectively. The lining is faced with blue brindle bricks.

The water in the surrounding ground, which finds its way to the brickwork lining of the tunnel, flows down the extrados of the arch into channels leading to chimney drains through fire-clay pipes built in the walls, and flows to either end of the tunnel through larger fireclay pipes laid on the formation close against the side walls.

The temporary works were situated at the north end of the tunnel, the chief of them being a protective overhead platform, a cement-shed, a 3 ton derrick crane, and electric-light and air plant. The overhead platform, besides being a convenience in dealing with the excavated and building materials, served to protect the traffic on the railway from the jib of the crane when in use. The cement-shed was capable of holding 100 tons of cement. The electric-lighting and air plant supplied light for the whole tunnel during the operations, and fresh air for the workmen, who, without it, would not have been able to remain in the tunnel for a reasonable time, owing to the presence of smoke emitted by engines passing through.

While the reconstruction was in progress, the traffic was worked on a single line of rails, laid in the centre of the tunnel. The actual work of reconstruction inside the tunnel was carried on with the aid of four steel travelling shields, the principal dimensions of which were 32 ft. long, 22 ft. wide and 16 ft. 8 in. high. There were openings through the shields, 13 ft. 8 in. wide and 13 ft. 6 in. high, for the passage of the trains. These openings were lined with timber, which served as a protection both for the traffic on the railway and for the workmen engaged on the top of the shield. Each shield consisted of two parts, which were connected rigidly together with bolts, and which could be taken apart if necessary. Small trolleys, running on narrow gauge lines, conveyed the excavated and building materials between the base of operations at the north end of the tunnel and the shields. They were assisted on Sundays, during the cessation of ordinary traffic, by waggons on the running-line.

The reconstruction of an originally lined portion of tunnel was comparatively simple, owing to the ground being rock. The shields merely acted as a protection, and were scarcely ever required to carry any load other than the weight of the workmen and of the building materials. The side walls were built clear of the shields, and ordinary tunnel centres were used for the building of the arch.

In the reconstruction of an originally lined portion of tunnel in soft ground, the old brick lining was supported off the leading

*Procs. Inst. Civil Engrs., Feb. ,1905.

end of the shield. A top heading was driven over the extrados of the old arch to allow of the two centre crown-bars being drawn. Then the old arch was removed, commencing at the crown, and the length was timbered as in ordinary tunnelling, the bars being supported on their back end off the new brick arch and at their front end off one of the ribs of the leading half of the shield. When a 12-ft. length was completely excavated and timbered, the rear half of the shield was detached and moved back to the last length, to be used as a scaffold in connection with the removal of timber centres. While the two portions of shield were apart, the opportunity was taken of building the side walls. Then the rear half of the shield was moved forward with the centres, which were erected in their new position, and another length of brick arch was built.

Alarm-bells connected with the signal boxes outside were provided at seven different points in the tunnel, and there was also telephonic communication between the middle of the tunnel and the same signal boxes. The drivers of engines were instructed to prevent as far as possible the emission of smoke and steam when passing through the tunnel, and to sound the whistles.

The time taken to complete a 12-ft. length of originally unlined tunnel was 7 days. The corresponding time for a 12-ft. length of originally lined tunnel in soft ground was 11 days, and for a 12-ft. length of originally lined tunnel in rock, 8 days. The average progress was 15 lineal yards per month per shield, the best progress of any one shield being 18 lineal yards per month.

The operations were carried on continuously, working night and day and on Sundays. There were three 8-hour shifts of miners in the 24 hours, and one shift of bricklayers, the number of men employed daily being 150. The reconstruction work proper inside the tunnel was commenced on January 27th, 1902, and was completed on December 25th, 1903. Single-line working through the tunnel was brought into operation on December 1st, 1901, and double-line working was resumed on March 6th, 1904.

The work was carried out by the Caledonian Railway Company under the direction of Mr. Donald A. Mathieson, M.Inst.C.E., assisted by the author; Mr. W. A. Kemp acting as Resident Engineer.

The Alfreton Second Tunnel.*

E. F. TRENCH, M.Inst.C.E.

THIS work was undertaken in 1899 as part of the Midland Railway Company's scheme for widening their main line in Derbyshire. The new tunnel is 90 ft. from the old, and, like it, is ½ mile in length. The tunnel cuts through the Coal Measures, and several beds of coal were met with, from which fuel for the contractors' engines, etc., was obtained.

Owing to the extensive cuttings required at both ends of the tunnel, it was not possible to attack it from the ends; five shafts were therefore sunk on the centre-line, and from these the whole of the tunnelling was done. The tunnel was driven of full size in both directions from each shaft, but when the working-faces had approached to within 2 chains of each other, a small heading was driven through, in order that the alignment and levels might be checked. In no case was there any appreciable error, although the only instrument used for setting-out the centre-line was an ordinary 5-in. transit theodolite.

The tunnel is built of red bricks procured in the locality, and is faced internally with best Staffordshire brindles. The thickness of the tunnel-ring is 2 ft. 3 in., except for a few lengths in which it is 2 ft. 7½ in., and the shaft lengths, which are 3 ft. thick. Most of the tunnel was worked in lengths of 15 ft., but at one point these had to be reduced to 12 ft., owing to extra pressure on the timbering.

A good deal of water was met with in driving the tunnel, and in order to drive this away from the working-faces, earthenware pipes were laid below the invert. The permanent drainage of the tunnel is effected by means of a 2-ft. brick culvert built on the invert. For turning the arch of this culvert, centring mounted on a trolley was used. This effected a considerable saving in time, and rendered it possible to build the culvert at the rate of 44 lineal yards per day. The drainage of the shafts is effected by means of earthenware pipes built in behind the brick lining of the shafts and tunnel, and discharging into the tunnel at rail-level. The water which accumulates around the shaft-lining is collected and led to these pipes by means of brick "garlands" encircling the shaft-linings just below the water-bearing strata.

The brickwork at the intersections of shafts and tunnel consists wholly of blue

*Procs. Inst. Civ. Engrs., Feb., 1905.

bricks in cement, the arris being formed of special bricks made to the proper angles. The permanent way through the tunnel consists of 100-lb. rails, which, before being laid, were painted with four coats of red-lead paint. The ballast is of slag.

Special care was taken, in designing and building the tunnel-fronts, to avoid the failures which sometimes occur at these places. The face-wall was built to a batter of 1 in 6, and in order that the brick courses of the tunnel-ring might be brought in normally to this batter, the tunnel was given a bell-mouth, the vertical axis being increased in length by 2 ft. at the face. To increase the longitudinal strength of the tunnel, hoop-iron straps were built between the brick courses at each face.

The time occupied in building the tunnel was nearly two years. The works were carried out at the direction of the company's engineer, the late Mr. J. A. McDonald, M.Inst.C.E. The contractors were Messrs. Thos. Oliver & Son, and the author acted as resident engineer.

Rolled Steel Car Wheels.*

SAMUEL M. VAUCLAIN, Supt. of Baldwin Loco. Works.

THE requirements for car wheels have risen very rapidly during the last few years, and wheels at one time satisfactory are now taxed beyond their limit by the more severe conditions of modern service. Loads have increased from 50 to 100 per cent., and it is impossible to increase the weight of the wheels in a like proportion, as the limiting factors were fixed before the high capacity wagons came into use.

The manufacturers of chilled cast iron wheels have been successful in meeting the demands which have been made upon them, but the brittleness of the flange, inability to resist the heating effect of the brake shoe, shelly treads (see Fig. 1), producing flat spots, and the internal stresses induced in the casting of such a wheel have given rise to the demand for a wheel free from these objections. This has been met by the introduction of the steel-tyred wheel. Steel tyred wheels of many designs have been made, their centres being of cast iron, cast steel and wrought iron, and of both plate and spoke form.

Standard wheels of well-known types, and in use under passenger and other high-priced equipment are considered too expensive for freight equipment, and even these suffer from shelly spots on the tyres or a variation in the density thereof, unless the utmost care attend their manufacture.

In Fig. 2 is shown an etched section of a defective and good tyre, the latter being dense and perfectly homogeneous, while the defective tyre shows a structure which is not uniform in density and contains other structural defects. What is required is a wheel, safe, durable and sufficiently low in price to compete with and finally supersede the chilled cast-iron car wheel.

The base of all processes necessary to make a first-class, solid forged, high carbon, rolled steel wheel is the long ingot. The process of manufacture is simple, the ingot being cut into sections, each of sufficient weight to make a wheel, and the upper or segregated section is discarded. Each of these sections is then pressed into shape under a 5,000 ton hydraulic press. From there by overhead cranes the blank is transferred to the rolls, where it is subjected to enormous pressure and revolved at a high rate of speed, emerging a perfect wheel.

Three etched sections of such a forged wheel are shown in Fig. 3; the quality of the material is unquestionable, and the wheels possess all the characteristics of the good tyre and none of the defective tyres. This is confirmed by the results of the physical and chemical tests.

FIG. 1.—SAMPLE OF SHELLED TYRE.

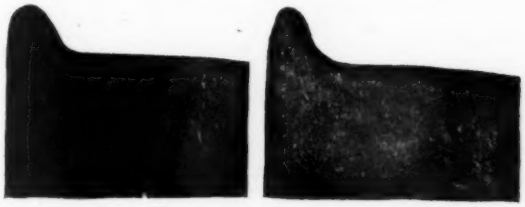


FIG. 2.—SECTION OF GOOD AND POOR TYRE.

* Journ. Franklin Inst., February, 1905.

FIG. 3.—ETCHED SECTIONS.

In the drop test a weight of 2,240 lb. was allowed to strike the wheel from various heights, and it took 13 blows to break a 36 in. wheel, 8 being from a height of 30 ft. Another wheel was tested in running position, and striking with a weight of 2,240 lb. it took 17 blows to fracture the wheel from rim to hub. Fig 4 illustrates a wheel after this test, which not only proves the severity of the test but the ability of the wheel to resist any stress it is liable to encounter in service.

The thermal test is one of the most severe that can be imposed upon chilled-iron wheels, and consists of pouring a ring of molten iron $1\frac{1}{2}$ in. thick and 4 in. deep against the tread, no cracks to develop within two minutes. This test is to secure a wheel which will not crack by the heat developed by the application of the brake shoes. The effect of this test on a number of rolled wheels was simply to cause the rim to expand and draw the hub down slightly. No fracture was produced, and the heat given out by the molten iron was sufficient to heat the tread for 2 or 3 in. to a dull cherry.

FIG. 4.—ROLLED WHEEL AFTER DROP TEST.

The comparison of the cost per 10,000 miles of solid rolled wheels and chilled-iron wheels is about 1·43 dol. as against 1·70 dol. The statistics vary from 1·65 to 1·78. The natural field for the rolled wheel is:—(1) The severe service of engine and tender trucks; (2) passenger car equipment, in which the element of safety plays an important part; (3) heavy freight car equipment. But they are, however, adaptable for lighter service.

In the ensuing discussion it was stated that though steel wheels were softer than chilled cast-iron wheels, the rate of wear was very much slower. If hard metal was used for bearings or car-wheels, the effect due to abrasion was that the particles instead of being elongated, were flattened out before being worn out, and were simply broken down and split off at a rapid rate.

Questioned as to whether any comparative tests had ever been made of the difference in rolling friction on the rails between steel and chilled cast-iron wheels, Mr. Vauclain replied that the rolling friction of the wheel played but a minor part in the total resistance of the train. In designing engines no attention was paid to whether the wheels were chilled iron or steel tyred, and an extensive series of experiments failed to show any difference in drawbar pull of a train equipped with steel tyred or chilled iron wheels.

Another speaker then stated that the wear of the *tread* of a well chilled cast-iron wheel was due to the action of the brake, which, in time, removed the surface and might cause "shelling out." The wear of the *flange*, which is important as to safety, was due to the friction of the side of the flange against the side of the rail, which reduced the thickness. The steel tyre must be of the same quality throughout and could be no harder than was consistent with strength, while the chilled wheel could be made hard on the tread and flange, while the body was soft and strong. It had always been found that the flange wear was greater in the tyre than in the wheel under the same conditions. What was the experience with the rolled steel wheel in this respect, having an almost uniform chemical analysis?

In his reply, Mr. Vauclain stated that the wear of flange is usually greater than that of tread, as in the former case there was sliding as well as rolling friction and in the latter rolling only. The strength of the rolled wheel increased with the hardness, but the ductility decreased.

Shipbuilding for the Navy.

LORD BRASSEY, K.C.B., Assoc. Inst. C.E.*

THE author pointed out that financial considerations could not be disregarded in dealing with this subject, and drew attention to the growth of the ratio of the military expenditure to the aggregate public expenditure of the United Kingdom during the past ten years, as compared with the ratios for Continental States.

The latest official statistics showed that England held a commanding position in the numerical strength of its fleet, but the rapidity with which vessels became obsolete made it imperative that the designs and principles of construction of future vessels should receive very careful attention.

Shipbuilding for the Navy must necessarily be an answer to construction in hand elsewhere, and as a first step in the consideration of the types which should be laid down for the British Navy, the author reviewed the work in progress for foreign navies, paying particular attention to the four vessels of the "Vittorio Emanuele" type, now building for the Italian Navy, and quoting recent opinions of the Committee of the Chamber of Deputies on the French Navy Estimates for 1905-6, as also of naval authorities on the question of the desirability of limiting the displacement of battleships.

In growth of dimensions England had always led the way, and in the hands of the skilful naval architects who were, or had been, her naval constructors, growing dimensions had given a more than proportionate gain in fighting efficiency; but on the other side various arguments could be advanced. In a naval battle numbers must tell, and if the units were less costly more of them could be built. Increase of size gave no immunity from the dangers of darkness and fog, from stranding or collision, from the ram, or the torpedo, or the submarine mine. Conning-towers could give no protection to commanders.

Consideration must be given to the hydrographical conditions in many parts of the seas in which British ships might have to fight. There were important harbours which heavy ships could not enter, and long stretches of coast which they could not approach.

The author was of opinion that it should not be difficult to design a high-speed vessel of the torpedo-boat-destroyer class, heavily armoured, armed with torpedo-tubes and with one heavy gun in the bows. Many of these could be built for the cost of one battleship, and they might do more than heavy ships to decide the issue of a hard-fought day.

He also suggested that some of the British battleships might with advantage be similar to those now being built for Italy and Germany, with a displacement of about 13,000 tons. Without advocating a revolution in shipbuilding policy, or desiring that England had a single big ship less on the Navy List, he contended that in future shipbuilding programmes some vessels should be included of a type suitable for narrow and shallow waters.

With regard to the submarine, the author remarked that it was essentially a defensive weapon. It was valuable for harbour defence, but its ability to navigate the seas had yet to be proved.

Turning to the consideration of cruisers, the author considered that the latest British examples would well bear comparison with those under construction elsewhere. Two types were necessary: scouts of the fleet, in which speed and coal-endurance were the essential qualities, and cruisers for the protection of commerce, in which fighting efficiency must be combined with these qualities. The latter type must be large. With regard to scouting cruisers, the author pointed out that the war in the far East had shown that cruisers having no protection by vertical armour could hardly be reckoned as combatants. He raised the question whether scouts could be supplied to the Navy without specially building for this service. Naval opinion was sceptical as to the value of the mercantile auxiliary, and some vessels have been put on the list of reserve cruisers which should not be there. For the Navy "Ocean greyhounds" only were needed. The author quoted the evidence given by Lord Charles Beresford before the Committee on Steamship Subsides, to the effect that only such ships, built as they were for speed in any weather, could perform the task as ascertaining and reporting with the utmost rapidity the movements of an enemy.

From the point of view of the Navy the arguments were cogent in favour of liberality in subsidies to such vessels, quite apart from the benefit to the Empire arising from swift inter-communication. Such vessels might also be utilized for the training of naval engineers and stokers. The Indian and other troopships, formerly so valuable for the training of the steam branch of the service, had ceased to exist.

*Proc. Inst. Civil Engineers. March 14th, 1905.

For scouting duties the essential feature was high speed. It was doubtful whether protection could be given by structural modifications without incurring excessive costs.

The author concluded by urging the desirability of discussion on such questions, which were of exceeding complexity and momentous import to the nation. It had been decided that the proceedings of the Admiralty Advisory Committee on Shipbuilding should not be made public. Such discussions as those which might from time to time be held under the auspices of the Institution of Civil Engineers were the more valuable for the guidance of public opinion.

A Universal Wood-Working Machine.

A MONTH or two ago a full illustrated description was given of a new universal wood-working machine, made by Messrs. Wadkin & Co., Leicester. Another machine of this type, embodying several interesting features, is now on the market, and, by the courtesy of the makers, Messrs. Thomas Robinson & Son. Ltd., Rochdale, we are now able to furnish some information concerning it. At the outset it may be stated, that the machine is the invention of Lovatt and Purser, Wolverhampton, Mr. Lovatt being the well-known contractor and Mr. Purser a foreman in his employ.

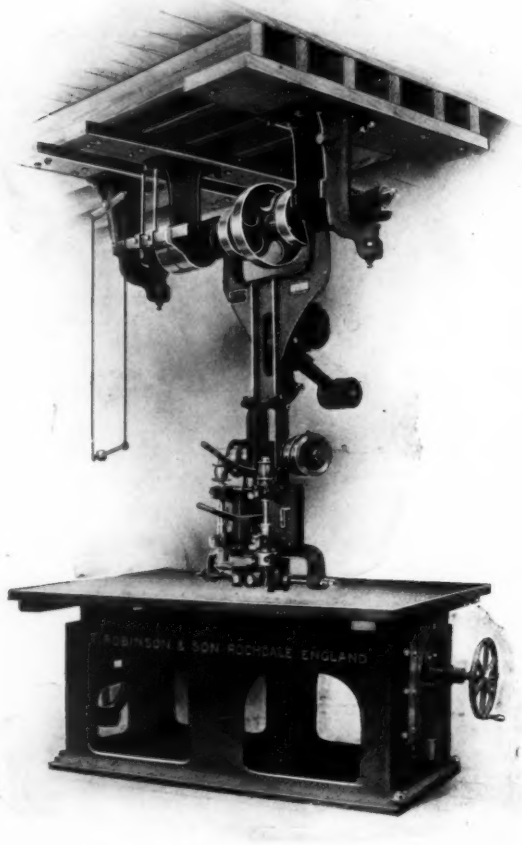


FIG. 1.—UNIVERSAL WOOD-WORKING MACHINE.

A perspective view of the machine is given at Fig. 1, which is reproduced from a photograph. By inspecting this carefully, and following the succeeding details, the main features of construction will be readily followed. The arm or frame, which is bifurcated at its upper end, is pendulous, and is suspended from trunnions which are carried in the bearings of fixed brackets bolted to the ceiling. The frame, which carries the various mechanism for driving and adjusting the cutters, is thus free to swing to and fro over the surface of the table at the will of the operator, but it can be readily held in any position out of the vertical by simply tightening up caps which pass over the trunnions at the supporting brackets. The axis of suspension of the arm is co-incident with that of the driving shaft which is carried by hangers as shown in the illustration, and on the shaft are carried three pulleys for driving the cutter spindles. The shaft passes through the trunnions, which are hollow, a clearance space being left between their inner surfaces and the shaft. At the lower

end of the swing arm and in the centre, a slider is mounted in vertical guides fixed to the frame. The slider is provided with four bearings, all having a common horizontal axis, the two centre bearings accommodating a spindle which has conical ends centred within adjustable portions of the two outer bearings. The spindle is driven by a pulley fixed on that portion between the two central bearings, a belt drive being used from the middle pulley of the overhead shaft. One side of this belt is in contact with the outer side of a jockey pulley carried by an arm rigid with the same first arm. The belt is by this arrangement kept automatically taut, whatever be the variation in the relative distances between the overhead pulley and the driven pulleys on the arm. On these portions of the horizontal cutter spindle between the middle and outer bearings, blocks are inserted to which the cutting tools are fixed. These lengths of the spindle are seven threaded, the cutter blocks being fixed in position by lock-nuts, but to prevent the spindle turning within the blocks, keys or feathers sliding along a groove in the spindle, have been provided.

Raising and lowering the slider and hence the cutters is effected by a hand lever, forked at its inner end and pivoted to the frame. Each side of the fork is connected with the slider by means of a link. At the lower end of the slider are carried two rollers, which are adjustable as to height, bearing on and travelling along the surface of the work. The limiting depth of cut is obtained by the adjustment of these rollers.

In addition to the main slider and spindle there are two secondary slides—one on each side of the centre line of the frame—each of which slides in horizontal guides fixed to the arm. Each secondary slide is provided with a pair of bearings accommodating a vertical spindle driven by a pulley attached to the upper end. The lower end a

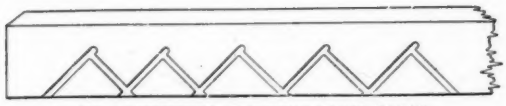


FIG. 2.—TRENCHING OR HOUSING STRING BOARDS.

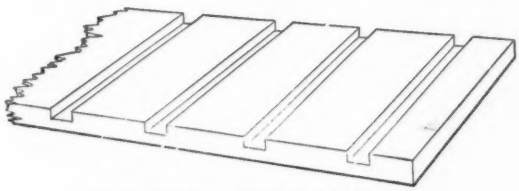


FIG. 3.—TRENCHING DIVISIONS FOR SHELVING.

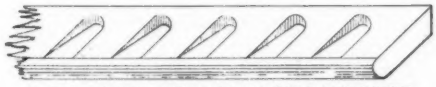


FIG. 4.—MACHINE TRENCHING FOR RIFLE BASE BOARDS.

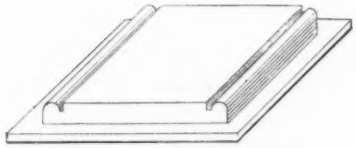


FIG. 5.—CURTAIN OR VALENCE BOARDS.

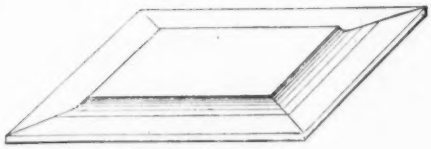


FIG. 6.—RAISED PANEL.

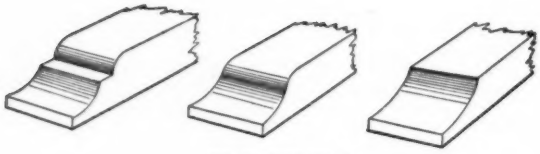


FIG. 7.—SASH TILES.

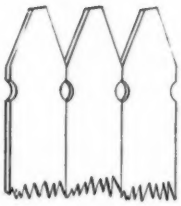


FIG 8.

head is formed to receive the various cutters. A belt drive connects each spindle pulley with one of the side pulleys on the overhead shaft, the belt being guided to and from the corresponding spindle pulley by means of guide pulleys having axes fixed in relation to the frame. A transverse carrying bar passes at its ends through portions of the secondary sliders, and a forked hand lever is pivoted to the frame, each side of the fork being connected by means of a link with the transverse bar.

This lever and secondary slides are held up by springs, the movement of the slides downward to bring the cutters into action being effected by the hand lever.

Each pair of vertical guides is fixed within horizontal guides, from which latter they may be loosened and thus slid towards or from one another to suit varying widths of work. It will thus be seen that the vertical spindles may be operated independently of the horizontal cutters. The work is first fixed on the table below the arm, the latter being swung aside to allow of this. The machine is started and the arm moved into position for the cutters to act upon the surface of the wood. The cutters are pres-ed down sufficiently to allow them to cut to the depth permitted by the rollers, for, as the frame is gradually moved upon its pivot axis as the cutting proceeds, the slide which carries the cutting-blocks moves vertically within its guides to adjust itself to the varying distance between the axis of suspension and the surface of the wood. The weighted belt appliance is so arranged that it causes the slide normally to be held up against a stop, or it may be arranged to have an opposite effect, and lower the cutters upon the work. In the former case the hand-lever is used for lowering the cutters, and in the latter for raising them.

The variety of work the machine is capable of will be well understood by reference to Figs. 2 to 8.

Fig. 2 is an example of trenching or housing string boards for stairs, only one set of cutters being necessary. A pair of boards 10 ft. long, can be worked in 15 minutes, and 96 pairs of treads and 11 risers can be worked in 50 hours. Fig. 3 shows trenching divisions for shelving, two trenches being cut at one operation 628 trenches $1\frac{3}{4}$ in. by $\frac{1}{2}$ in. have been cut in eleven hours in timber 33 ins wide. Fig. 4 is another example of trenching, while Fig. 5 shows a panel, sixty of which can be beaded and moulded in an hour. In raised panel work, Fig. 6, the capacity is forty panels 22 in. by 11 in. per sixty minutes. In horning sash tiles, Fig. 7, sixteen are worked at one operation, the time occupied being two minutes. The last example, Fig. 8, is for curtain or valence boards, of which 2,000 a day can be turned out.

A Combined Steam Hammer and Hydraulic Press.

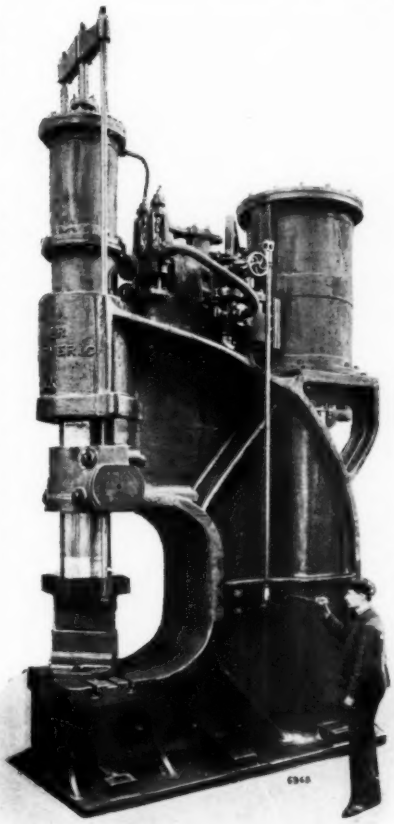
THE hydraulic press possesses, in comparison with the steam hammer, important advantages, at least as regards high power apparatus. For low power plant the steam hammer still continues to be used, as it affords the very special advantage of working rapidly, and giving a large number of blows within a certain time, which cannot be expected of a press. On the other hand, the forging press possesses a quantitative output much superior to that of a large steam hammer, because, as a general rule, the effect produced by one throw of the press is much superior to that of a steam hammer, and the working rapidity of the two machines is almost identical. Another advantage of the press in comparison with the steam hammer, is to be found in the improvement in the quality of the work forged.

With a view to combining the advantages of small and medium sized steam hammers with those of high power hydraulic presses,

Messrs. Brener, Schumacher & Co., of Kalk, near Cologne, have recently introduced a combined arrangement, using simultaneously steam and hydraulic power. This is done in such a way that, whilst securing the speed of a steam hammer, the pressure under the hammer may, it desired, be maintained for an unlimited period. Furthermore, the new machine not only enables work to be forged but also bent as may be required The power varies according to the type from 200 to 500 tons.

The external appearance and general arrangement of the machine is shown in the accompanying photograph. The working distribution of the two forces brought into play is as follows: the steam controls all the movements which have an influence upon the speed of the work, whilst the hydraulic power provides the necessary pressure.

In order to combine the two forces, an hydraulic pressure cylinder of cast steel is bolted upon the frame, which is also of cast steel; whilst the steam cylinder utilized for raising the hammer, is arranged above the hydraulic cylinder. Below this latter are the guides for the control of the hammer. Directly the hydraulic pressure ceases the steam piston raises the hammer. Another steam cylinder, also mounted on the frame, actuates the driving mechanism. The cylinder of the pump is connected by means of a cross-bar and two rods to the piston of a steam cylinder, so that the water, issuing from the cylinder of the pump, is sent under pressure into the hydraulic cylinder. The metal to be treated is thus compressed directly the steam is admitted below the piston of the steam cylinder raising the hammer. When on the contrary, the steam cylinder raises the hammer the water is expelled from the pump cylinder. When commencing work a special arrangement enables the hydraulic cylinder to be filled with water from a tank. At the moment when the actual forging operation is carried out, the steam cylinder working the pump has, therefore, only to supply the required pressure upon the water contained in the cylinder of the press. In this way the consumption of steam is considerably reduced.



COMBINED STEAM HAMMER AND HYDRAULIC PRESS.

Description of Mixer for Concrete.

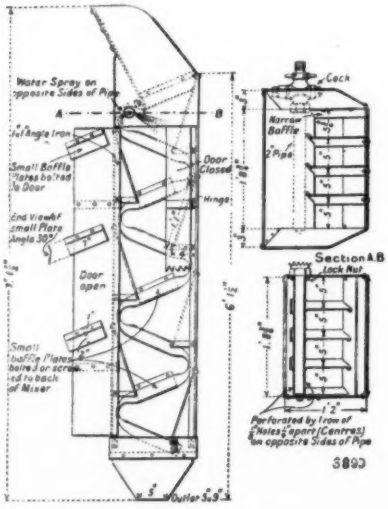
A SIMPLE but effective mixer, designed by Dr. J. S. Owens, Ashford, Middlesex, is shewn in the accompanying illustrations. It consists of a shoot made of wood or iron in which baffle plates are fixed on opposite sides and sloping downwards. Perforating the lower or free edges of these baffle plates are a series of long sinuously bent and twisted bars, so arranged and hung as to be in effect narrow baffle plates deflecting at right angles to the line of deflection of the larger plates, and also where each large plate is perforated by these smaller ones the deflection is in an opposite direction from that at the edge of the plates immediately above and below it. The mixing is effected by the continual splitting up into separate

CONCRETE MIXER.

columns of the material thrown at the top, and the throwing together of these columns again, the process being repeated eight or nine times in a 6 ft. mixer, and the aggregate thoroughly mixed with the cement.

A most important advantage of this mixer is the efficient mixing of the water with the concrete and the production of a cement properly wetted and free from slurry. This is attained by the method in which the water is supplied. It enters in a spray behind the lower edge of the top baffle plate and thence downwards follows a variety of paths, some trickling down the sinuous bars and thus traversing a path about twice as long as that of the concrete; some dripping from one large plate to another; and some tumbling in a spray with the concrete. The result is that the working parts are covered by a film of water, upon which the concrete falling becomes wetted, owing to the mixer being hung vertically. There is little wear in the machine, the parts being all practically fixed. The sinuous bars, however, are so arranged as to vibrate when struck by the falling material and so prevent clogging. All parts can be easily removed or renewed if necessary, doors being provided for this purpose and to remove large stones and clean the mixer. The method of working is very simple:—The ballast having been gauged is spread to about 9in. deep and the gauged cement spread over this evenly, the edges are then thrown up on the centre and the whole turned towards the hopper of the mixer. The water being now turned on the materials are shovelled steadily into the hopper at the top and the feed being kept steady until the heap is exhausted, they fall from the outlet as thoroughly mixed concrete.

The capacity of the mixer is about 80 yds. per day if worked constantly. The cost being only £25 it soon pays for itself. It is, of course, specially suited for work in foundations, sea-walls, &c., when the work is below the place of delivery of ballast and cement. It can be arranged to deliver into trolleys running underneath which is usually the most economical way of working. The mixer has now been in use for about a year, giving very satisfactory results.



DETAILS OF CONCRETE MIXER.

Standard Specification for Portland Cement.

THE latest and one of the most important specifications issued by the Engineering Standards Committee is that relating to Portland cement*, which has been prepared by an exceptionally strong sub-committee, who, during twelve meetings, collated and considered a large amount of information.

The preliminary portion deals with the quality and preparation of the cement; the sampling and preparation for testing and analysis, sampling at the manufacturer's works, fineness, and specific gravity. The following are the conditions to be complied with as to chemical composition:—

> There shall be no excess of lime, that is to say, the proportion of lime shall be not greater than is necessary to saturate the silica and alumina present. The percentage of insoluble residue shall not exceed 1·5 per cent.; that of magnesia shall not exceed 3 per cent.; and that of sulphuric anhydride shall not exceed 2·5 per cent.

The mode of gauging and the formation of briquettes for testing is next prescribed, the tests being as follows:—

> Briquettes of neat cement of the shape prescribed shall be gauged for breaking at 7 and 28 days respectively, six briquettes for each period. The average tensile strength of the six briquettes shall be taken as the accepted tensile strength for each period. For breaking, the briquette shall be held in strong metal jaws, of the shape shown, the briquettes being slightly greased where gripped by the jaws. The load must then be steadily and uniformly applied, starting from zero, increasing at the rate of 100 lb. in 12 sec. The briquettes shall bear on the average not less than the following tensile stresses before breaking:—
>
> 7 days from gauging, 400 lb. per sq. in. of section.
>
> 28 days from gauging, 500 lb. per sq. in. of section.
>
> The increase from 7 to 28 days shall not be less than:—
>
> 25 per cent. when the 7 day test falls between 400 lb. to 450 lb. per sq. in. of section.
>
> 20 per cent. when the 7 day test falls between 450 lb. to 500 lb. per sq. in. of section.
>
> 15 per cent. when the 7 day test falls between 500 lb. to 550 lb. per sq. in. of section.
>
> 10 per cent. when the 7 day test is 550 lb. per sq. in. or upward.
>
> *Sand Test.*—The cement shall also be tested by means of briquettes prepared from one part of cement to three parts by weight of dry standard sand. The proportion of water used shall be such that the mixture is thoroughly wetted, and there shall be no superfluous water when the briquettes are formed. The cement and sand briquettes shall bear the following tensile stresses:—
>
> 7 days from gauging, 120 lb. per sq. in. of section.
>
> 28 days from gauging, 225 lb. per sq. in. of section.
>
> The increase from 7 to 28 days shall not be less than 20 per cent.

The concluding paragraphs deal with the setting time and tests for soundness. The Chatelier method is prescribed for the latter, the cement in no case to show a greater expansion than 12 mm. after 24 hours aeration and 6 mm. after 7 days.

* British Specification for Portland Cement. London Crosby, Lockwood & Son. 2s. 6d. net.

Application of Electricity to Industrial Purposes.

J. F. C. SNELL, M.Inst.C.E.

IN the course of a recent paper on this subject*, the author dwelt more particularly upon the relative advantages and costs of independent and co operative generation of current, concerning which he gave some valuable figures and information. After shewing from two instances that the variation in cost per unit generated from separately driven plant of respectable dimensions varied from 1·08d. to 1·173d., he stated that in works requiring from 300,000 to, say, 1,000,000 units per annum, and with a load factor of 20 to 30 per cent., the cost would be found to vary from 1·25d. per unit to 1d. On the question of supply from outside sources it was pointed out that the first and most obvious saving would be in capital outlay per kilowatt, and a curve (Fig. 1) was given showing the relation of the cost per k.w. between stations varying from 250 k.w. up to 10,000 k.w. Quoting from the paper:

> "Many independent plants do not exceed 200 kilowatts in extent, while the two power stations referred to have actually exceeded or are nearing the higher limit. Now, if, as the diagram shows, the smaller installation cost £45 per kilowatt installed, it is obvious that the 10,000 kilowatt station, costing about £20 per kilowatt, can afford to spend money outside the station in laying adequate cables and fixing the necessary transforming machinery, and yet

* Procs. N.E. Coast Inst. Engrs. and Shipbuilders, Feb. 24th, 1905.

be able to effect a considerable saving on the capital sum

Secondly, it must be equally obvious that, while a decent load factor of anything between 15 and 35 per cent. even may be obtained in an independent installation, yet the combination of a dozen, and, *a fortiori*, several dozen such works in one station, must result in a far better load factor which is actually in practice found to be anything from 45 to 55 per cent.

The scale of prices upon which a power station may be reasonably expected to supply current is shown in Fig 2. This scale is based upon the practical capital cost of a large power station equipped with modern appliances, and the remaining figures of fuel, stores, wages and other establishment charges, are taken from actual practical results.

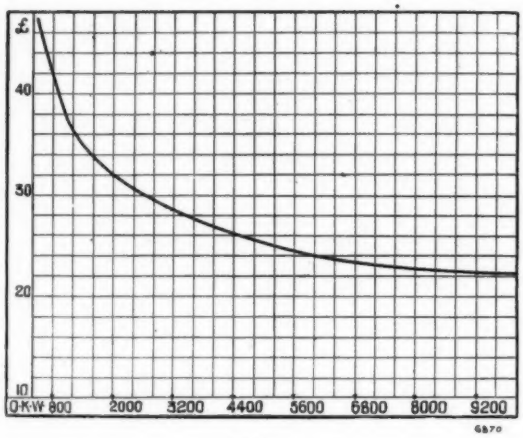


FIG 1.

Reference to Fig. 3, which deals with the cost of a small local station installed for the supply of large works, demonstrates at once the influence of the capital cost upon the units generated, and the economy which can be obtained from the concentration of many such mall installations in one big power station.

From a comparison of the two diagrams, the following results are obtained for outputs of 100,000 or more units per annum :—

Load Factor.	Units per K.W. Demanded.	Price from Power Supply.	Price from own Local Station.
Per Cent.		Pence.	Pence.
15	1,314	1·5	1·75
20	1,752	1·25	1·45
25	2,190	1·125	1·25
30	2,628	1·00	1·10
35	3,066	0·875	0·95
40	3,504	0·800	0·90
50	4,380	0·75	0·75
60	5,256	0·68	0·65
70	6,132	0·66	0·58
80	7,008	0·62	0·50

The deductions to be made show that the higher the load factor of a particular installation, the less reason is there for the purchase of power from an outside company, and the more excuse for installing one's own plant ; and that at a load factor of 50 per cent. the costs are identical, and that for load factors above 50 per cent. the power can be more economically generated on the spot. This only applies to exceptional plants, such as pumping or paper mills working continuously, and does not apply to engine works and shipyards having a load factor of under 40 per cent.

As to the merits of direct current and alternating polyphase currents. The advantages of the direct current are : variation of speed over a considerable range, without undue loss of economy, and with utmost simplicity ; and in favour of the three-phase motor, the utmost simplicity of mechanical and electrical construction, the total enclosure of the motor, and absence of commutator and of any wearing parts other than the bearings, which are themselves negligible.

The costs and weights of motors are in favour of the three-phase type. The starting and stopping are quite as easily and as economically carried out, and the only objection which one can offer to the three-phase motor is its less easy variation in speed when compared with its direct current competitor.

In point of efficiency, the direct current motor has the advantage at present, and is probably, from physical reasons, likely to continue to have that advantage,

There is only one more point to mention, but one by which a manufacturer starting to electrify his works can save a good deal of capital outlay. Wherever possible, it should be the aim to group the machinery and tools in such a way as to adopt three sizes of motor, and let us say, for example, 30 h.p., 15 h.p. and 5 h.p. In this way a spare armature for each type of motor will probably be found to be sufficient, and thus the capital expenditure on spares will be considerably reduced.

It is quite true that a complication ensues in many cases from the variety of speeds at which tools have to be driven, but the author does

not think that this is as bad as is made out, and in special cases, rather than instal a fourth size of motor, he would be inclined to modify the speed through gearing of some kind, even at the risk of some loss in efficiency. Then, the starting switches, the switchboard panels and instruments could be made, say, of two sizes to suit the three classes of motor, and thus there will be some system instead of the too frequent and too great variety of instruments one sees installed.

The arc lamps should be, if possible, of the same pattern, and the resistance or choking coils in connection with them should be of precisely the same pattern. Thus a very simple and easily understood system will be adopted with a resultant minimum first cost. If continuous current dynamos be installed, the adoption of the three sizes suggested can also be probably arranged; and the same size of carbon brush (though a different number of each, of course) can be utilised, and thus only one size and style of carbon be kept in stock.

One of the greatest difficulties which manufacturers have is to ascertain the size of motor to attach to certain machines. In any case, with direct current installations, it is always advisable to have the motors compound wound, and in cases of intermittent work, such as with punching and shearing machines, as an extreme example, it is necessary to supplement the motor by a heavy flywheel.

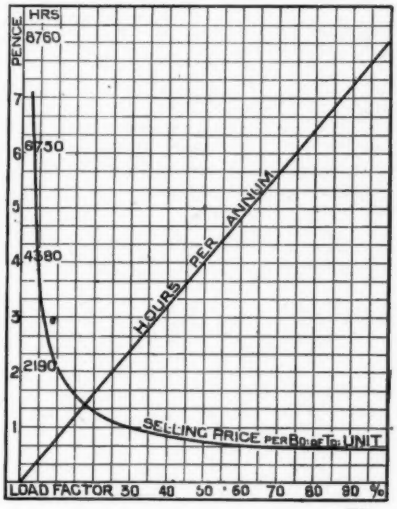


FIG. 2.

The author, in conclusion, expressed his confidence that transmission in the future in workshops and other factories would be almost entirely by electrical means, and one important point he asked users to remember was the quicker rate of doing work which frequently resulted from the adoption of electricity. He asked manufacturers to look at the cost of their power squarely There were too many instances of such figures as ½d. per horse-power hour, or less, being given, which, when analysed, were soon proved to contain merely the cost of fuel and stores —not the whole of the wages, and only a vague idea of the repairs, with no provision for depreciation of plant, rating, interest on capital outlay, or general superintendence He knew in many works it was difficult to arrive at a true assessment of some of these figures. That we have entered an era of the almost universal adoption of electricity, he was quite certain. At the same time, manufacturers should not hastily adopt the new method, but should take time in laying out their works to the most economical advantage.

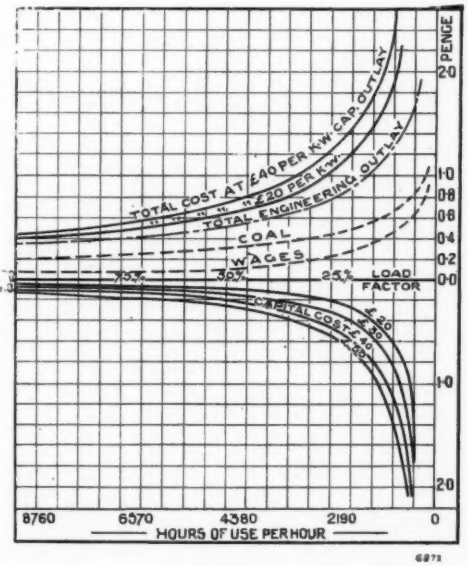


FIG. 3.

An Interesting Bridge Launch.

THE construction of a bridge may be simple, but the erection of the same is governed entirely by local circumstances, and in countries where timber for false-work is scarce, and the cost of skilled labour is high, it is necessary to seek such means of handling the work in the field as will entail as small an outlay as possible for these items.

The particular work to which attention is called, is the erection of several steel bridges for the Central Bahia Railway, South America. The design for these bridges was prepared by Mr. B. J. Forrest, M. Can. Soc. C.E., who recently presented a short paper to the notice of the society of which he is a member, describing the method of erection. The bridge selected for description is one of 203 ft. length spanning a deep gorge, the base of rail being about 180 ft. above water level, and the sides of the gorge being very precipitous.

The difficulty of successfully designing the bridge was enhanced by the fact that this portion of the country is liable to severe shocks of earthquake, and suitable provision was made for the supports of the trusses, as will be described later.

Owing to the cheapness and facility of procuring cement and stone, the abutments and wing walls were built of concrete, the concrete being braced and tied together with old rails and tie bolts, as indicated, since it was found that the adjacent rock was cracked and fissured for a considerable depth. The general lines of cleavage of strata ran north and south, and the direction of oscillations east and west.

The method of erection of the bridge was as follows: Steel suspension ropes 1-5 8 in. diameter were carried across the gorge, resting on wooden roller bents at each abutment and connected to a winch at each end. Each half span was assembled, one on each side of the opening, and hauled to the beginning of opening, then the second panel of each from the centre was securely bolted to the hinged top of a temporary wooden braced boom 80 ft. long, which was pivoted on the rock face of the gorge as shown on plan. Near the centre panels of the bridge were placed roller bearing shoes, which rested on the 1-5 8 in. suspension ropes. The suspension ropes were stiffened by the use of 5-8 in. steel wire rope guys; these were used for alignment, and in assisting the hauling ropes in starting, stopping, balancing and controlling the travel of trusses. The shore ends of the trusses while being launched rested on skids, the ends being counter-balanced as much as possible during the launching. These skids rested on rails, and are shown in the illustration. Powerful screw jacks were used when these skids jammed.

Hauling ropes of ¾ in. steel were attached to the trusses, the hauling being accomplished by the aid of a locomotive.

When the ends of the half spans met at the centre of the opening, the closing up and adjustment was done by means of jacks and four powerful cam jaw levers bolted to upper and lower chords of trusses, thus holding them in position while the joints were being riveted up. When this was done the centre and end cross girders

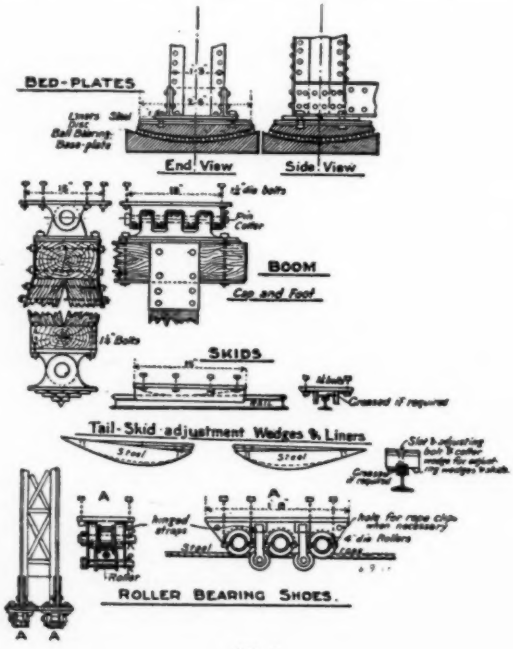


FIG. 1.

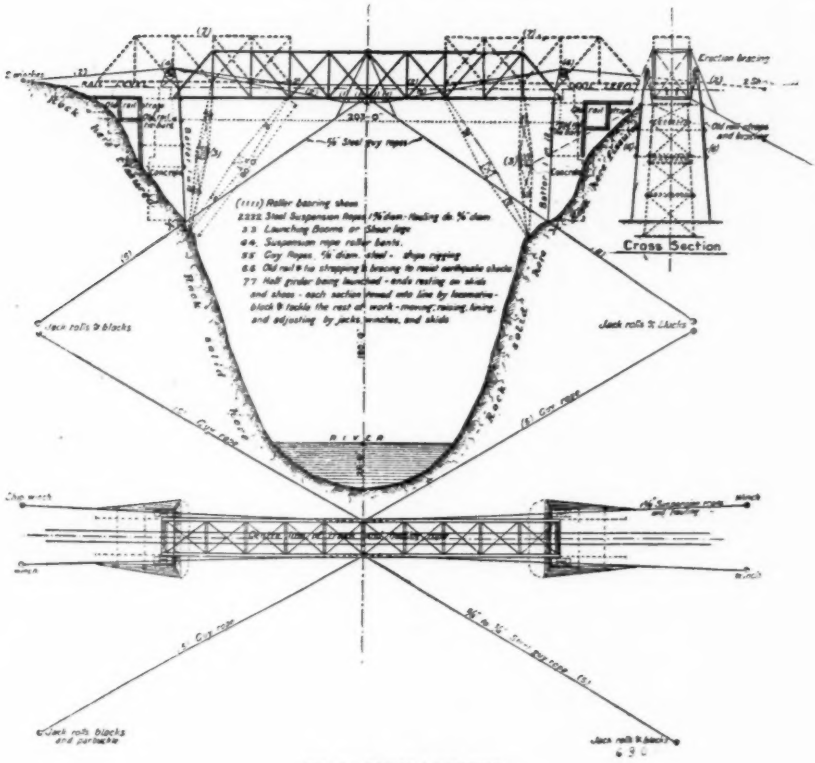


FIG. 2.—BRIDGE LAUNCHING.

and gusset plates and spandrels of upper and lower chords were placed in position, and after these the wind bracing, laterals, floor beams and joists.

The greater weight of the truss was carried on the 80 ft. boom, and the trusses were assembled at such a height that, when the two halves met together, the lowering of the top end of booms would bring the trusses to the necessary height to suit the finished rail level.

Special end bearings had to be designed to allow provision for displacement by earthquakes. As will be seen, the shoes were of disc form, resting on a number of balls, these in turn resting on bed plates of a suitable dished form. This form of bearing was found to work in a very satisfactory manner during earthquake shocks, which gave oscillatory motion at centre of span of about 3 in., with no signs of cracks or settlements of abutments or wing walls. The total weight of the bridge as launched was about 120 tons, thus giving a load on each launching boom of about 30 tons. Provision was also made for adjusting the rail approaches by the use of four moveable track entrance trussed beams, 12 in. by 18 in., fixed at each end of bridge, one end being strapped and bolted to side of end floor beam, the other end resting on cross beam bearers, skids and wedges, for facilitating alignment and levelling up of track entrances into bridge after earthquake shocks or settlement of ground.

Maximum deflection at centre estimated at 2½ in. The main joints of trusses at the centre, as also the gusset plates, were riveted, all other connections being bolted, chiefly on account of lack of skilled labour, and with a view to facilitate speedy erection.

Work at the National Physical Laboratory.

THE report of the work done during the year 1904 at the National Physical Laboratory was issued by the Executive Committee at the general board meeting held on March 17th, on which occasion many distinguished visitors took advantage of the opportunity afforded them of inspecting the buildings and equipment.

While the results achieved are of the utmost scientific importance and of very real interest, the work that the institution is capable of doing is hampered by lack of equipment, and it is with regret we notice that many requests for help have had to be declined owing to the incompleteness of the equipment and the insufficiency of the staff. The increasing demand for scientific assistance in many branches of industry renders imperative the establishment of an institution in a position to satisfy that demand, otherwise its growth will be checked and the results will be disastrous. We believe that science can do much to aid commerce and manufacture, but the attempt to do this must be on a fitting scale.

The grant of £4,000 per annum made by the Treasury is to be raised to £5,500 for 1905-6, an entirely insufficient amount when it is seen what other countries are doing in this direction.

The sum falls considerably short of the amount of £10,000 which, as the Committee pointed out in their Memorandum, will, in their opinion, be ultimately necessary to discharge the duties which have been laid upon the Executive Committee, while the long period over which the work of equipping of the laboratory is to be spread will make its full development slow.

The following are some of the details of the most important work carried out:

ELECTRICITY.

Standards of Resistance.—An inter-comparison has been made of the mercury standards of resistance constructed last year. The differences found were in agreement (within the limits of the errors of observation) with those previously observed.

The methods of building up resistance coils, having values in ohms approximately equal to some power of 10, have been investigated. The evaluation of a 10-ohms coil, by placing 10-unit coils in series, or by Lord Rayleigh's most convenient "build up" of three 3-ohms coils capable of being placed in series or in parallel, is not sufficiently accurate for standards purposes. Build-up boxes have been designed consisting of coils having resistances in the ratio of the numbers 1.1.2.2.5.10, the arrangement of the coils being such that the lines of flow are of the same form when the separate coils are being evaluated, as when they are placed in series. No contacts form part of the resistance measured, and careful checking proves the build up to be accurate to 0.0001 per cent.

Standard Cells.—The investigation of certain anomalies of Clark and cadmium cells has been continued. Special four-limb cells were constructed, designed so as to contain three different samples of any one element of the cell. In this way the instability of the samples was determinable. Mercurous sulphate was the first substance to be investiga ed, the observations of previous years indicating its behaviour to be most unsatisfactory. The investigation proved the sulphate, as ordinarily prepared, to be quite unsuitable for standard cells, and

The following table is of interest as showing what has been done in other countries:—

Country.	Name.	Cost.		Annual Grant.	Receipts for Work, Annual.	Number of Tests.	Staff.
		Building.	Equipment.				
		£		£	£		
Germany	Reichsanstalt .. .	200,000		16,000	3,000	22,469	112
	Aichungs-Kommission	48,800		8,500	—	—	—
Prussia ..	Versuchsanstalt ..	137,500		15,000	9,000	5,000	140
France ..	Laboratoire d'Essais..	27,000	20,000	5,500	—	—	12
U.S.A. ..	Bureau of Standards..	70,000	45,000	19,000	114	1,666	22
England ..	National Physical Laboratory ..	19,000	—	4,000	4,042	30,807	50

a standard method of preparation was sought Three methods proved to be successful. The first of these is a modification of one due to Divers and Shimidzu, the salt being prepared with fuming sulphuric acid and mercury. The second is a precipitation method, while the third is an electrolytic method, due to Prof. H. S. Carhart, Mr. G. A. Hulett, and Dr. F. Wolff. Very satisfactory results were obtained. Six cadmium cells, prepared with samples of mercurous sulphate so made, were taken to the United States by Dr. Glazebrook in September, the object being to compare their E.M.F.'s with those of other cells constructed by Prof. Carhart. Unfortunately, the cells changed in transit; the reason for this is unknown, but will be investigated. There is little doubt, however, but that a depolariser can now be prepared, such that the E.M.F.'s of cells prepared with samples manufactured at different times will not be different by more than a few hundredths of a millivolt. With purchased samples of mercurous sulphate, cells were prepared having E M.F.'s different by more than two millivolts.

An investigation has also been made to determine the difference, if any, of E.M.F. between the H form of cell and the tube or Board of Trade form. Since 1892 the H form has been assumed to have a smaller E.M.F. by 0·0004 volts. Cells combining the two forms were constructed, and observations made on both Clark and cadmium cells. The results showed conclusively that no difference so great as four ten-thousandths of a volt exists; the difference, if any, must be very small.

A preliminary report on the anomalies of standard cells was presented to Section A of the British Association at Cambridge.

In the coming year it is hoped that the investigation will be completed, and a satisfactory specification for both Clark and cadmium cells prepared. The various objections against both kinds of standards when subjected to a fluctuating temperature will also receive attention.

Ampère Balance of the British Association.—The construction of the electrical portions of this has been the principal work of the year. The weighing mechanism was completed by Mr. L. Oertling in April, and was tested at Mr. Oertling's works, the results being entirely satisfactory.

The four marble cylinders for use with the balance have been wound and successfully insulated. The turning and screw-cutting of these was performed by Mr. Taylerson, of the Engineering Department of the Laboratory. The two large fixed cylinders have diameters of 13 in., and are each 11 in. long. The small suspended cylinders are 8 in. in diameter, and approximately 6 in. long. On each fixed cylinder are two double helices of No. 24 bare copper wire. The pitch of each helix is 1·18 in., so that the air space between consecutive turns is less than six-thousandths of an inch. Double helices are also wound on the small cylinders. The object of the double helix is to enable the insulation resistance between the strands to be measured. Initially, this insulation resistance was surprisingly low, and great difficulty was at first experienced in raising it to more than a few hundred ohms. Finally, however, an insulation resistance greater than 30,000 megohms was secured for each pair of coils.

To obtain the mean diameter of the coils measurements were made in nine or ten approximately equidistant planes, and fourteen observations made in each plane. A complete survey of the surface of the coils was thus ensured. The measuring apparatus was specially designed, and enabled the diameter of any turn to be determined. Readings could be repeated to one micron. The observed diameters have been plotted so as to illustrate the ellipticity and conicality of the cylinders. The average ellipticity is such that the diameters of the ellipse vary by about 10 micron, while the average difference between the maximum and minimum means of the readings in the various planes is about 12 micron. This latter is a rough measure of the conicality. The dimensions of the coils are probably known with greater accuracy than any coils hitherto constructed.

Many accessories for the balance have also been constructed, and there still remains much delicate fitting to be done. The outlook for a speedy determination of the absolute unit of current is, however, very hopeful.

THERMOMETRY.

The chief research in the department has been the commencement of a study of the resistance and thermo-electric properties of solid electrolytic conductors, such as are used in Nernst lamps, with a view to the design of a system of electrical high-temperature measurement based on some of the properties of these materials.

Tubular electric furnaces have been constructed capable of continued use at temperatures well above 2,000 deg. C. By means of these furnaces and a number of thermo-

junctions of widely different properties, whose E.M.F. in terms of the standard temperature scale up to 1,300 deg. C. had been previously determined by extended comparisons with the Laboratory standards, a careful determination of the melting-point of platinum was made, using six different junctions for temperature measurement and four different samples of platinum. The results of the different determinations, which were closely concordant, are to be published shortly.

The existence, at high temperatures, of large thermo-electric forces between rods of the various earths, made up and treated as ordinary thermo-junctions, has been securely established by direct electrometric methods, and the apparatus necessary for a detailed study of these phenomena is in course of construction.

METALLURGY.

Tests.—These include the following investigations, some of which have led to very interesting results:—

An Inquiry as to the Possible Causes of Fracture of Four Boiler Plates during Welding under a Steam Hammer.—It was first shown that strips cut from the fractured plates could be welded without showing any flaws. A thorough microscopic examination of the faulty parts of the welds showed that in all cases these had been primarily caused by an oxidation of the metal surfaces during the welding treatment, for at each place where a crack originated there was an accumulation of oxide of iron among the iron crystals, and it is well known that such oxidation prevents an effective weld from being produced. The investigation, however, showed that one of the plates contained a latent flaw, which was developed into a wide crack under the steam hammer. This flaw could be traced over the whole section under examination. It was quite different in character from a weld in that it was visible to the naked eye, but was barely distinguishable under microscopical magnification at 150 diameters. Where this flaw came under the steam hammer it had widened out to a crack.

A Microscopical Examination of a Strip Sheared from a Brittle Butt Strap Plate showed that up to a maximum distance of about ⅛ in. from the sheared edge the two structural constituents (ferrite and pearlite) are distorted in such a manner that they are drawn out into threads roughly parallel to one another and to the sheared edge, but that otherwise the distribution of the structural constituents was normal. No cracks, either between or across the ferrite and pearlite areas, were visible.

An Investigation as to the Cause of Fracture of an Unused Steel Rail which broke during Unloading on to the Railway Track.—Chemical and photomicrographic analyses both testified to the uniform character of a fractured rail. The former, however, showed a high phosphorous content, the latter a well-marked parallel arrangement of and sharp junctions between the two main structural constituents. The condition of the rail appeared to be one of general brittleness, attributable to the high phosphorus content and the extreme lamination of the structural constituents.

A Microscopical Examination of a Boiler Plate which had Failed under the Hydraulic Test, while it showed that the structure of the plate in the neighbourhood of the main fracture differed in two respects from that of the body of the plate, viz.,

(1) in the very irregular distribution of the ferrite and pearlite areas,

(2) in the greater clearness with which the ferrite and pearlite areas were defined,

did not render it possible to connect casually the structure near the fracture with brittleness. Further, some experiments carried out by us to imitate this particular structure were unsuccessful.

(e.) *The Range of Solidification and the Heating and Cooling Curves of Metals, Alloys, and Slags* have been measured.

(f.) *An Examination of the Structures of Duplicate Samples of Copper Cable, the one Used, the other Unused*, did not point to any ageing action in the used tube. The outer (thin) tubes had a finer structure than the inner (thick) tubes. The type of crystallisation was sharper and more angular in the used than the unused tube; otherwise there appeared to be no difference.

Two researches have been completed during the year.

(1) *A very wide Range of Properties of a Series of Nickel, Carbon, Manganese Iron Alloys, prepared by Mr. Hadfield at the Hecla Works, Sheffield, has been carried out.* The originally prepared series contained eight members. At an early stage, however, it was found desirable to prepare two more alloys on account of the abrupt change in

the properties between 4 and 8 per cent. nickel. The full series is as follows:—

Laboratory No.	Percentages.		
	Nickel.	Carbon.	Manganese.
39	Nil	0·47	0·95
40	1·20	0·48	0·79
41	2·15	0.44	0·83
42	4·25	0·40	0·82
43	4·95	0·42	1·03
44	6·42	0.52	0.92
45	7·95	0·43	0·79
46	12·22	0·41	0·85
47	15·98	0·45	0·83
48	19·91	0·41	0·96

The tests made on this series may be divided under four heads:—

Mechanical.

1. Tensile tests—
   (*a*) Yield point.
   (*b*) Ultimate strength.
   (*c*) Extension.
   (*d*) Reduction of area.
2. Young's modulus.
3. Compression tests.
4. Bending tests.
5. Impact tests.
6. Repeated loads tests.
7. Hardness tests.
8. Torsion tests.

Chemical.

9. Composition.
10. Corrosion.

Physical (including Metallographical).

11. Specific gravity.
12. Dilatation.
13. Electrical conductivity.
14. Permeability.
15. Range of solidification.
16. Cooling and heating curves.
17. Photomicrographs in relation to mechanical, heat, and cold treatment.

The tests have in every case been carried out on the forged "normalised" alloys, *i.e.*, on the forged material heated to 800 deg. C. and allowed to cool in a muffle to the ordinary temperature. The alloys with 6·5 to 16 per cent. nickel were very difficult to machine, and required special preliminary heat treatment.

The results obtained will be presented shortly to the Alloys Research Committee of the Institution of Mechanical Engineers.

(2) *An Investigation of the Critical Ranges on Heating and Cooling of Modern High-speed Tools* has been carried out with a view to throwing light, if possible, on the changes that occur during heat treatment in works practice. The results have been correlated to structural changes. The tempering of these steels has also been investigated. The results will be submitted to the Carnegie Research Committee of the Iron and Steel Institute by Dr. Carpenter, one of the Carnegie Research Fellows for the year 1904.

ENGINEERING.

The testing equipment of this department has been extended during the year by the addition of an impact testing machine, which has been constructed in the workshop. In this machine the notched specimen is supported on a pair of adjustable knife edges carried by the anvil, the blow being delivered by a swinging hammer in the centre of the specimen. Both the anvil and the hammer are suspended by thin steel tapes from overhead shafts and swing in the same vertical plane. The weight of the hammer is 46·7 lb., and that of the anvil 60 lb. The anvil and hammer are provided with arrangements for measuring their displacements before and after impact, so that the total absorption of energy in impact can be directly measured.

A tank with the necessary appliances for testing water meters is being fitted up owing to inquiries made for tests of this nature.

A machine for testing gutta-percha cord in tension, and autographically recording the load and extension, has been designed and made in the workshop, following to some extent the arrangements adopted at the Silvertown Works.

The number of tensile tests on steel has greatly increased during the year, but the necessity for a larger testing machine is strongly felt, the present 10-ton machine being inadequate for many of the tests demanded.

A vibrating platform for the testing of pressure gauges subject to vibrations of varying periods and amplitude, is being designed in accordance with the arrangements made with the manufacturers of pressure gauges.

The provision of the new lathe for use with high-speed cutting tools, which has recently been procured for the workshop, affords increased facilities for the cutting tests on tools which are now undertaken by the department.

The Standard leading screw lathe has been fitted with a new compensating bar and a microscope holder for purposes of measurement. One screw for Messrs. Sir

W. G. Armstrong, Whitworth & Co. has been cut, and work is now proceeding on three screws which have been sent from Woolwich Arsenal. Complete sets of tools for cutting these screws have been supplied by the makers of the lathe, but in future these will be prepared in the Laboratory workshop. A complete set for any screw consists of 14 tools, the total number of cuts being 106, exclusive of the cuts necessary for rounding and undercutting the threads. At the fixed rate of cutting, the times of completion of one screw varies from two to three weeks. This could be reduced by adopting a quick return motion for the tool rest, but, from considerations of the extra wear involved, it has not been thought advisable to accelerate the return motion.

The following are some particulars of the research work carried out by the department:—

The Effect of Wind Pressure on Structures.—A revolving steel frame for carrying the pressure plates and models of structures has been made and fitted to the 50-ft. steel tower erected for the purpose of observations on wind pressure. By this means the pressure surfaces can be kept normal to the wind during the observations. Preliminary experiments have been made on a flat plate 10 ft. long by 5 ft. broad. The velocity of the wind is measured by a Dines pressure tube placed 5 ft. in front of the pressure plate, and which is connected to a tilting gauge on the ground by a pair of lead pipes attached to the framework of the tower. A considerable number of pressure orifices have been made in the pressure plate, any two of which can be connected by similar lead pipes to another tilting gauge at the foot of the tower. By means of simultaneous observations of the two tilting gauges, the velocity of the wind and the pressure at any point of the pressure plate referred to the pressure at its centre can be obtained. It is found that the maximum pressure comes on in gusts of so short a period that a large number of observations are necessary for each orifice in order that a fair average can be obtained. In this way a considerable portion of the plate has been surveyed so that a comparison of the distribution of pressure on plates exposed to the wind and to a uniform current will be obtained. With reference to the resultant pressure on the plate, it was hoped that it would be possible to balance the effect on a large plate against that on a similar small plate, but no definite results have so far been obtained by this method for the case of the two similar plates, 50 sq. ft. and 5 sq. ft. in area respectively, which have been attached to the platform. Preliminary experiments on similar plates of 5 sq. ft. and 1 sq. ft. in area, which were made before the erection of the tower, had led to the conclusion that such a method might be adopted, but apparently it is not suitable for pressure plates of considerable area. Careful observations of the intensities of pressure at corresponding points of the two plates afford the following explanations of the difficulty of balancing the pressure on one plate against that on the other:—

(1) The intensity at corresponding points on the windward sides of the two plates is rarely the same, sometimes the intensity of pressure on one plate preponderating, and sometimes the other, by as much as 25 per cent. of the whole intensity.

(2) The intensities of pressure at corresponding points on the large plate often differ considerably from each other in value, especially in the horizontal direction. This is most likely due to the wind not striking the large plate normally, veering as it does through a considerable angle with great rapidity.

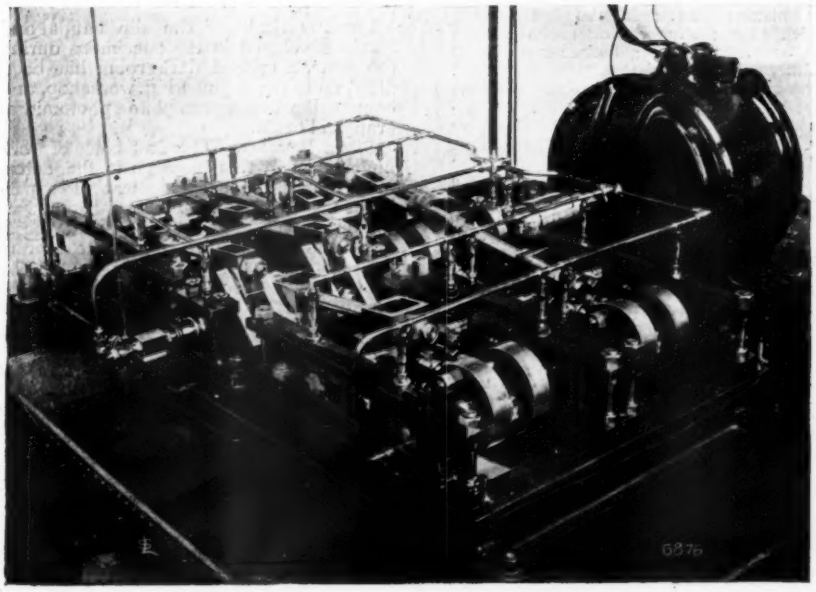
As regards the general results of the observations made up to the present time, it would appear that the distribution of pressure on the windward side of a large plate in the open air is not identical with that over a small plate exposed to a uniform current of air, the intensity of pressure falling off more rapidly from the centre to former case than in the latter. The ratio of the pressures on the windward and leeward sides appear to be practically the same in both cases.

The Resistance of Materials under Alternating Stresses.—The testing machine for carrying out these experiments has been completed, of which the following is a brief description (gathered from a fully illustrated account that appeared in the columns of *Engineering* on February 17th, 1905:—

It was decided to adopt the method of Professor Osborne Reynolds* in the design

* This machine consists of two weights moving in straight lines at right angles to each other, the specimen forming a connecting link between one of the cross heads and the weight reciprocated thereby, the other weight being simply for the purpose of balancing the first. It is run off a rotating crank shaft, by means of two connecting rods having a common centre at the crank-pin, and the motion is practically periodic. The alternating stresses are approximately equal, and the number of alternations is limited to 2,500 per minute, being partly due to the vibrations produced by higher speeds. An extremely valuable paper giving the above machine in detail, together with the results of the tests carried out, was read before the Royal Society in 1902 (see *Eng. Rev.*, Vol. II., No. 3).

for the National Physical Laboratory machine, with the modification that four cranks operating four specimens should be employed instead of one. By introducing this modification a machine could be made, the moving parts of which would be perfectly balanced, the speed of rotation practically constant, and which would allow of the comparison of four different qualities of material under exactly the same stress conditions throughout the life of the specimens. The chief objection to this four-cranked arrangement was that it practically entailed the horizontal motion of the masses, but it was hoped that the consequent frictional effect could be made so small as to be negligible. A further advantage lay in the fact that with four cranks the method of balancing could be made independent of the ration of the crank arm to the connecting rod, so that a length of crank arm could be adopted which would enable experiments to be made at considerably lower speeds than those obtained by Professors Reynolds and Smith, which were in no case less than 13,000 per minute. Further, the results of the high speed trials ranging from 2,400 to 13,000 alternations per minute showed that for a given range of stress the life of the specimen depended largely upon the period of the alternation; so that it was considered most desirable to extend the observation to speeds which are more commonly obtained in practice. A general view of the machine is given in the accompanying illustration, from which it will be seen that the machine consists of two independently-balanced systems on the same crank shaft, each system being made up of two cranks placed at 180 deg. to each other, with the connecting rods, cross heads, and specimens at opposite side of the crank shaft —an arrangement involving the use of split connecting rods on one side. The cranks of the second system are placed at right angles to those of the first, so that the kinetic energy of the rotating parts shall be approximately constant, thus keeping the fluctuations of speeds during a complete revolution as small as possible. The crank shaft is a mild steel forging completely balanced in itself. The main crank pins are 3 in. in diameter and 4 in. long, and have a 2 in. radius; so that, allowing for a total weight of 130 lb. attached to each crank pin, the intensity of pressure on the surfaces has a maximum value of 858 lb. per sq. in., at 11,000 revolutions per minute. For experiments at speeds varying from 11,000 to 2,000 revolutions per minute, a crank shaft of smaller throw is employed. To lubricate the crank pin journals a hole is bored through the centre of each end of the shaft passing through the crank webs to



ALTERNATING STRESS MACHINE AT THE NATIONAL PHYSICAL LABORATORY.

the centres of the three crank pins on either side, the oil being fed under pressure to each end of the crank shaft through stuffing boxes fixed to the bed plate.

The main cross head consisted of a hollow gudgeon pin, 2½ in. in external diameter, fitted with cast iron slipper blocks working in cast iron guides on each side.

The secondary cross head, which formed the mass whose inertia produced the stress in the specimen, was also fitted with cast iron slipper blocks and with cast iron flitch plates symmetrically bolted on either side of the centre, so that the total mass could be varied according to the stress required.

The form of the specimen was practically the same as that adopted by Reynolds and Smith,* consisting of a turned bar of the material under test, 5 in. long and ¾ in. in diameter, cut down in the centre to ¼ in. in diameter for a length of ½ in., the two ends being screwed ¾ in. Whitworth to fit the holders.

In fixing the specimen into the machine, it is first screwed into the fork of the main cross head and locked with a nut. The long nut at the other end is then run back to the secondary cross head and locked to it by a pin. The specimen is then rigidly coupled to the long nut, which is split at its forward end, by means of the two screws shown in the section.

The slipper blocks in the secondary cross heads are bored out and fitted with solid pistons and rods, the latter being coupled to the slipper blocks of the main cross head. Indiarubber buffers are placed on either side of the pistons, with very small clearance, as it is well known that specimens under alternating stresses break without permanent extension or contraction. To give warning of the fracture of a specimen, four small bell-crank levers are attached to the bed plate, in such a position that on the fracture of any specimen the slight displacement of the secondary cross head due to the compression of the buffers brings it in contact with one arm of the lever, the other arm dipping into a mercury cup and completing an electrical circuit, which rings a bell. This arrangement was found to work quite satisfactorily.

The machine is driven by a Mather & Platt electric motor, mounted on the same bed plate, and coupled direct to the crank shaft by a modified Oldham coupling. The motor is provided with a speed regulator, by means of which the speed can be varied in steps from 50 to 2,000 revolutions per minute, and with a carbon resistance for regulating the speed between any two steps. By this means the fluctuation of mean speed for any trials can be easily regulated, so as not to exceed 1 per cent. A speed indicator is attached to the crank shaft of the machine, and a counter giving total revolutions to the shaft of the motor.

The main bed plate carrying the machine and motor is suspended by four ½ in. steel rods from cross girders above, there being perfect freedom of the whole arrangement as regards lateral movement, and hence any slight want of balance in the moving parts can be immediately detected.

The maximum tensile stress on the specimens is 1.4 times the value of the maximum compressive stress, which is approximately the ratio of the stresses in the piston rod of an ordinary reciprocating steam engine. In the case of the small-throw crank shaft which is to be fitted to the machine, the stresses will be practically equal in value, and it is hoped that a comparison of the results obtained in the two cases will throw considerable light on the effect of the range of stress on the life of the specimens when the values of the limiting stresses are varied.

The machine has been used for determining the resistance under alternating stresses of a series of specimens for the research of nickel steel of the metallurgical department.

As the consumption of oil during the tests is considerable, a steam purifier has been fitted up and connected to the experimental boiler, so that all the oil passing through the machine can be cleaned and used again.

For the study of the slip bands and cracks developed in the specimens during the tests, a special dark room has been fitted up in the engineering workshop, and equipped with a complete photomicrographical outfit.

Steam Research.—The first piece of work undertaken in this research is the determination of the specific heat of superheated steam. The method adopted is the direct measurement of the heat necessary to raise a known weight of steam from and to any temperatures chosen. The steam is heated by an electric current flowing through a coil of wire, and the energy needed is measured by means of an accurate volt and ammeter. A temporary apparatus was constructed in order to test the method and obtain some approximate values for the specific heat. This was in the first instance provided with mercury in glass thermometers. These were found to give considerable trouble, owing to the continuous changes of zero they underwent, in spite of a very thorough annealing before use. It was therefore decided to provide the outfit for measurement of the temperatures with platinum resistance thermometers before continuing the experiments.

* See *Eng. Rev.*, Vol. II., No. 3, p. 174.

These thermometers are constructed in the usual way, with fine wire wound on mica frames, the resistance being about 2·6 ohms at 0° C. The thermometers are enclosed in steel tubes 1 cm. in external diameter, and these tubes are placed directly in the steam.

The bridge used for measuring the resistance is of the type used by Prof. Callendar, with some modifications in detail to suit the special circumstances. The slide wire is 50 cm. long and about ½ ohm resistance. The bridge unit is the change of resistance produced by a shift of ½ cm. on the wire (= nearly .01 ohm). The coils in series with one end of the wire are 350, 50, 50, 50, 50, 50, 50, 50 units respectively. Thus with the first coil only the two fixed points, 0° C. and 100° C., are both on the slide wire, the "fundamental interval" of the thermometers being adjusted to be 100 bridge units. The addition of each coil afterwards causes a shift in the position of the slider of one-half the length of the wire, so that there are always two positions where balance can be obtained. This gives a very convenient check of the accuracy of the bridge. For these experiments two temperatures are always required, that of the inlet steam and that of the outlet. These may differ by a large quantity, and in order to obtain them quickly it was necessary to duplicate some parts of the bridge. This was done by providing two copper bars, one connected to each of the compensating leads from the thermometers, and to each of which any number of the coils can be connected independently. Two sliders are also provided, one for each thermometer. A six-pole mercury cup switch is provided, making, with one shaft, the circuit through either thermometer, the corresponding compensating lead with the coils arranged and the corresponding slider. Thus the coils and sliders are always set for each temperature and either can be read by shifting the switch into one position or the other.

In the same box is placed a thermo-electric key, a series resistance in the galvanometer circuit with a turning head and a battery switch and reverse. The only detached parts of the apparatus beside the thermometers are the galvanometer and battery. The coils are all of manganin wire, so that temperature changes do not affect the reading, and the contacts are made by large mercury cups, so that trouble with contact resistances does not occur.

As the thermometers are adjusted to the bridge unit the readings are direct in platinum degrees, conversion to centigrade degrees being made afterwards by means of tables The bridge has proved very handy in use, and with a sensitive galvanometer of quick swing, it is possible to take an observation of each temperature within ten seconds.

During the preliminary tests it was found absolutely necessary to have perfect control over the heating current, to obtain which a large resistance frame has been constructed. The main frame contains 29 coils, regulating the current from 5 to 20 ampères and controlled by a 30-point turning head. A second turning head with 30 points is provided, one turn of which corresponds to the shift of one step on the first head. Thus nearly 900 steps are obtained between 5 and 20 ampères. The heads are of special design to prevent any alteration in contact resistance affecting the adjustment.

By means of this resistance the watts in the circuit are kept constant during any experiment to a fixed reading on a 3,000-watt wattmeter.

During the year improvements have been made in the insulation of the heating coil from the case. The superheater is now lined with a glass tube, and the leads have been enclosed in glass tubes. a satisfactory steam joint having been devised.

Petrol Locomotive for Light Railways.

THE locomotive shown in the accompanying illustrations is typical of a design now being introduced by the Wolseley Tool and Motor Car Company, Ltd., Birmingham, for use on all kinds of light railway track, factory tramways, light junction railways, and for mining and quarry equipments.

The locomotive illustrated was actually built for a 2 ft. 9½ in. gauge railway, but other sizes are made to suit particular requirements; the gauge, wheel base, height of buffers, loading gauge, etc., being specially considered with reference to individual cases.

The makers point out that there are numerous advantages attaching to a locomotive of this type. For instance, the running expenses are less than of a steam locomotive: there is no visible exhaust, and by the use of a large muffler or exhaust box of a large size the running of the motor it-

self is rendered very quiet. The u ilization of an internal combustion engine for this type of work of course does away with the necessity of consuming fuel when not in work, an advantage which is of the first importance in light railway work where that service is almost ent rely intermittent and irregular.

A locomotive of this description possesses all the advantages claimed by the makers of light railway electric installations, and, in addition to that, requires no expensive permanent way, fixtures, nor the establishment of an elaborate central station.

The engine, which is equipped with a heavy fly-wheel to render it capable of starting readily with heavy loads, is constructed throughout on the standard lines so long adopted by the "Wolseley" Company for their motor car engines, with this important exception, that it is very much more substantial in construction, and the use of aluminium has been entirely eliminated.

The bearings are of ample size, and every provision has been made to ensure regular running for a very long while. For all ordinary purposes the locomotive is fitted with four coupled driving wheels, of a wheel base sufficient to enable it to negotiate the smallest curves on which it is to run.

The frame is of stout channel steel stiffly braced by similar transverse members with ample gusset plates.

The hornblocks are of cast steel, and bolted direct to the frame. In the smaller types of engines these hornblocks contain spring boxes for locating the spiral springs, on which the engine is supported. For larger sizes a suitable combination of laminated and spiral springs is adopted.

The power is taken from the motor by means of a "Renold" silent high speed chain. One chain wheel for this drive is mounted on the crankshaft of the motor immediately outside the fly-wheel, the other one being carried on the first motion shaft of the specially constructed gear box. This same shaft carries a powerful friction clutch of suitable design, which is conveniently operated from the driver's seat.

The gear box has special features, and is illustrated in Fig. 5. It is supported by universal nose suspension on the forward end, and on two ample bearings on the rear axle itself. This renders the box entirely self-contained and enables a perfectly rigid drive to be obtained for the final gear, which consists of a broad tooth spur pinion wheel carefully cased in, running in grease. It will be readily seen, therefore, that both the engine and gear box are entirely self-co ntained and unaffected by any stresses set up due to unequal twisting of the main frame.

This is an extremely important consideration for light railway work, where locomotives of this type are liable to be subjected to extremely rough handling during shunting operations, etc. The "Renold" chain provides an extremely flexible drive between the engine and gear box.

The change of speed is effected by means of sliding gears and a positive clutch, the

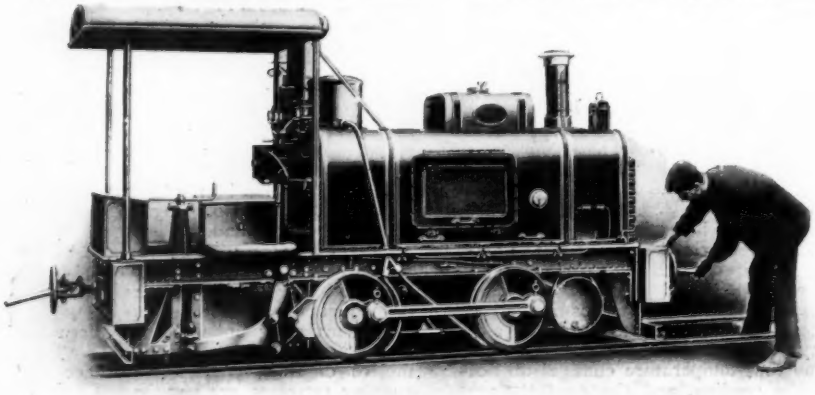


FIG. 1.—PETROL LOCOMOTIVE FOR LIGHT RAILWAYS.

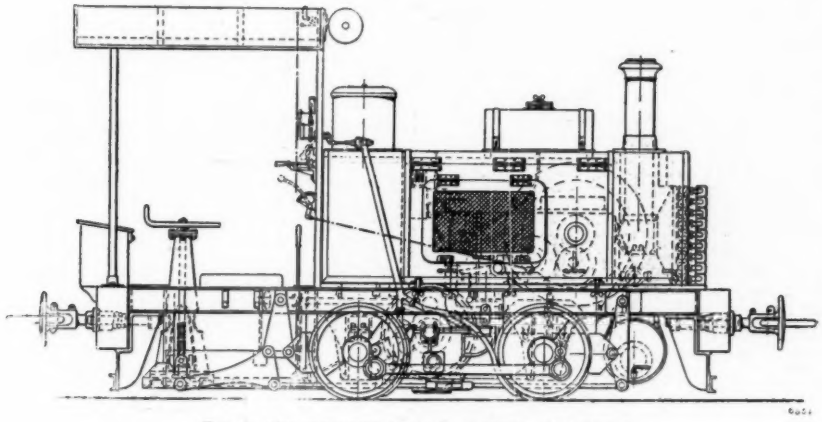


FIG. 2.—SIDE ELEVATION OF 6 × 7 × 2 PETROL LOCOMOTIVE.

whole forming a very substantial job specially designed for long life.

The cooling is arranged with a battery of radiators exposed to the atmosphere in front and subjected to the induced draught of air caused by the rush of the exhaust up the chimney. A large ballast tank is provided, and the circulation system, which includes a high speed pump, keeps the engine quite cool, although standing with the engine running for long periods.

The capacity of the petrol tank is ten gallons.

Powerful brakes, hand-actuated, are fitted, and the brake blocks are differentiated from side to side.

A suitable kit box is provided with an outfit of spanners, oil cans, petrol funnel, starting handle, etc.

The driver's seat is placed on the near side of the locomotive, and all the control apparatus, change speed levers, lubricators, ignition gear, brakes, etc., are conveniently placed thereabouts.

The whole of the motor is neatly cased in and provided with inspection doors on each side. The exhaust is carried upward through the chimney, substantially as shown on drawing. A light canopy is provided for the driver.

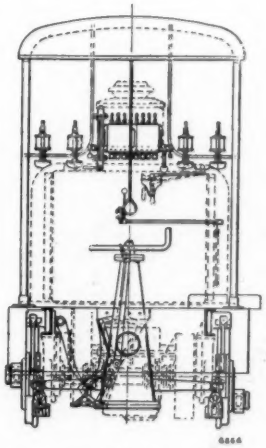


FIG. 3.

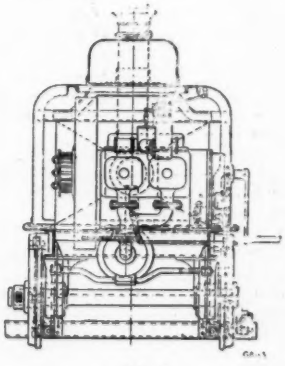


FIG. 4.

PETROL LOCOMOTIVE: END ELEVATION.

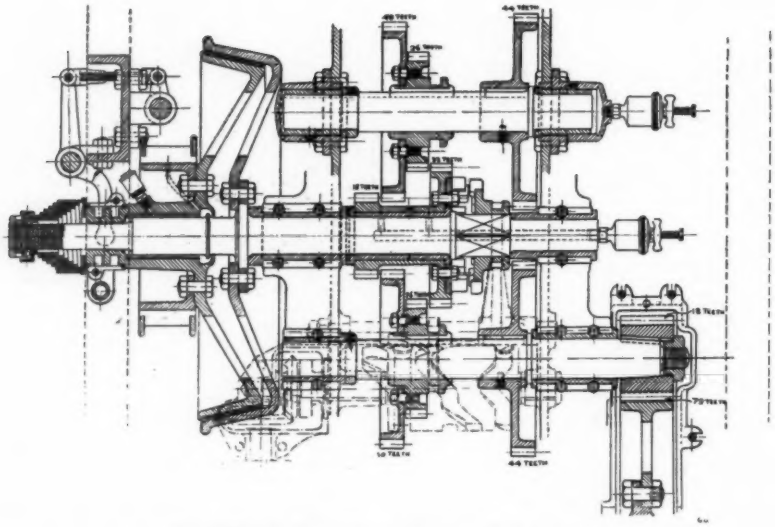


FIG. 5.—PETROL LOCOMOTIVE: DEVELOPMENT OF GEAR BOX.

An Improved Stop Valve.

THE accompanying illustrations are those of an improved form of stop valve recently introduced by Messrs. J. Hopkinson & Co., Ltd., Huddersfield, and for which several advantages are claimed. The most important of these is that the valves are independently operated by their own spindles in opposite directions to the centre of the valve when closed, and in this position the pull of the one counteracts the thrust of the other, thus relieving the valve body of all mechanical strains and ensuring fluid tightness of the valve.

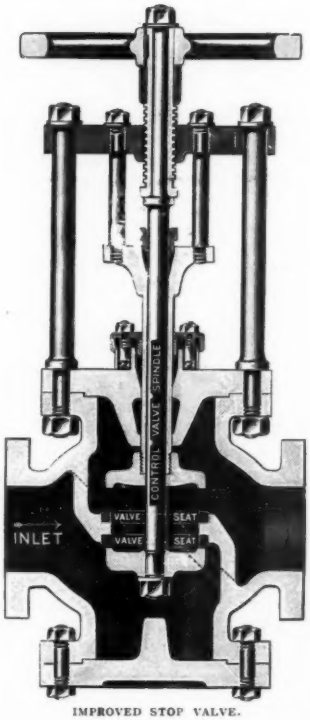
Further, the manipulation is easy and the valve remains steam tight under high pressure and without the application of any considerable force.

It will be seen that the valve consists of a simple valve body with a duplex central seating having two valves and working in opposite directions on each side of seat. The main valve is connected to the floating bridge and is raised or lowered with it. The control valve at the bottom is operated by an independent central spindle, which can be separately rotated. The hand-wheel in turn operates both valves.

On turning the hand-wheel in the usual direction the screw, which is keyed to the wheels, is revolved, the floating bridge is raised This action lifts the carrier and the main valve with it until the valve is full open from its seat as shown.

On continuing to turn the hand-wheel in the same direction, the floating bridge, which has by this time engaged with the stops, ceases to travel, and becomes a fixed nut; the spindle goes on revolving and the bottom or control valve opens and permits the passage of steam through the top or main valve, which is now wide open.

To close the valve, the hand-wheel is revolved in the usual dire tion. The control valve closes first and shuts off the steam; the pressure underneath this valve obviates the necessity of applying any force to hold the control valve to its seat, and the upper valve can be closed down without any exertion other than that required to overcome the friction of the stuffing box. It will, therefore, be seen that all pressure is above and below the same seat, obviating any one-sided thrust or pull.



IMPROVED STOP VALVE.

Automatic Hoist.

An interesting hoisting installation has recently been made at the warehouse of the Northern Counties Cold Stores and Ice-making Co., Ltd., Newcastle-on-Tyne, by Messrs. J. S. Hall & Co., Ltd., of Newark-on-Trent, to whom we are indebted for the following particulars:—

The building to which the elevator has been applied is a six-story warehouse. Every floor is served, the articles consisting of frozen carcases, barrels of butter being transferred from one floor to the other at the rate of 700 per hour. The elevator consists of a pair of endless chains, made up of malleable iron links, running round sprocket wheels placed at the top and bottom of the building, the lower pair being driven through worm gearing by means of an electric motor. At intervals between the chains are suspended cradles, the end plates of which swing from special links. Connecting the lower end of each pair of plates is a rod on which are mounted six Y-shaped brackets, so designed as to suit the shape of the various objects to be conveyed. As the forks forming the bed of the cradle pass upwards, they pass at each floor level between sets of arms upon which is placed the article to be hoisted, to be lifted off by the forks. Levers are provided for every set of arms, in order that they can be turned to a vertical position and so be thrown out of action, the two halves of each set being actuated simultaneously. Delivery is effected from the descending side of the elevator, the cradle forks passing at the floor level between sets of arms upon which the object is deposited.

The delivery arms are inclined at a suitable angle to suit the nature of the object carried, so that the article will slide off.

The cradle always maintains a vertical position, the suspending pins rotating in

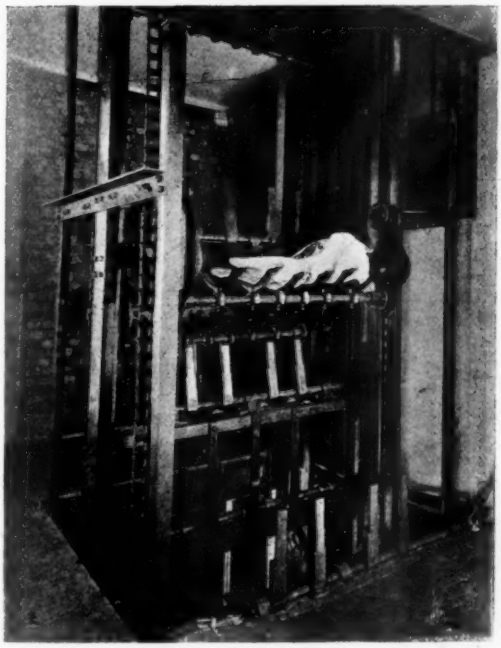


FIG. 1.—AUTOMATIC HOIST.

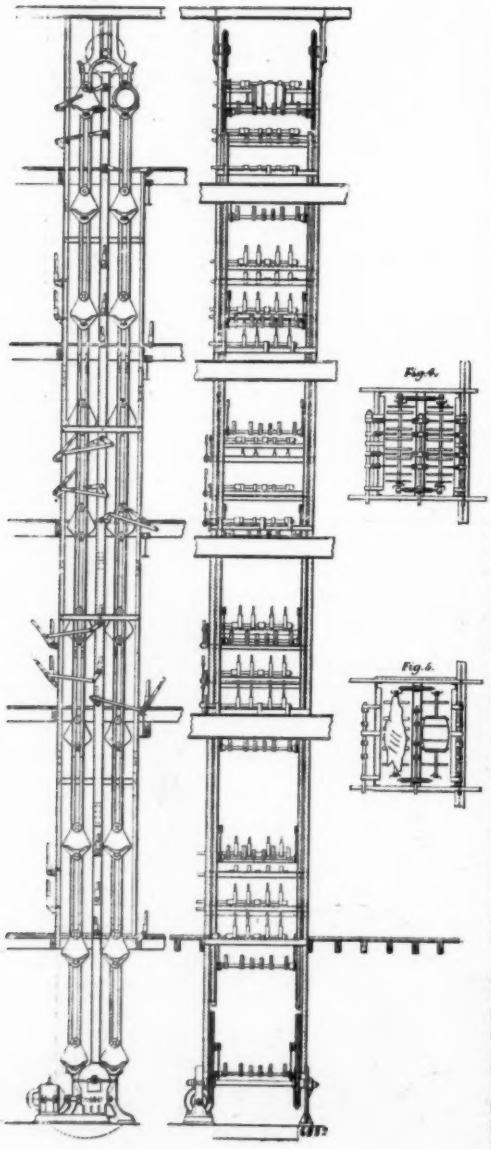


FIG. 2. FIG. 3.

DETAILS OF AUTOMATIC HOIST.

the links of the chain as the latter pass round the sprocket wheels.

In the accompanying illustrations, Fig. 1 is a half-tone of the hoist at floor level. Figs. 2 and 3, side and front elevations, showing the loading arms and delivery arms on the third and fifth floors in working position. Figs. 4 and 5, plans, the former showing a cradle passing between the loading and delivery arms, the latter a loaded cradle.

The Moore-Heskett Direct Process for the Manufacture of Wrought Iron and Steel.

THIS is a process designed for the treatment of iron sands or pulverized concentrated iron ore in a fine state of division.

Fig. 4.

Fig. 5.

The apparatus consists of an upper and a lower brick-lined revolving cylinder attached to a gas furnace. The cylinders are lined with fire bricks and have several brick shelves running along their whole length. They are placed at an angle of length about 10 per cent. from the horizontal, and revolve slowly. The finely-divided ore is automatically fed into the upper cylinder, and is continuously lifted up by the shelves, and made to fall in a fine spray as it travels to the lower end. The inside of the cylinder is maintained at a low red heat by waste gases passing through it from the gas furnace to the chimney. The heated particles of ore, as they are delivered from the lower end of the upper cylinder, fall into a lower cylinder through a vertical flue, and are delivered into the upper end of the lower cylinder at a red heat. This is connected at its upper end to a gas producer or retort, and is the channel through which the reducing gas is delivered to the gas furnace. The vertical flue between the two cylinders is so arranged that the sand can enter the lower cylinder, but the gases cannot enter the upper one. As the fine red hot particles of ore travel through the lower cylinder, they are constantly lifted up and made to fall through the reducing gases as in the upper cylinder, and are delivered at the lower end in a continuous stream, falling into the bath of the gas furnace below, where the deoxidized sand is melted as fast as it accumulates.

The process can be carried out automatically from the ore to the fluid steel. Each separate particle of ore is made to fall a great number of times through the heating and deoxidizing atmosphere, kept at a suitable temperature below its fusing point. Under these conditions heating and deoxidation take place in a few minutes. The reduced ore then falls directly into a bath of molten metal, which is maintained at a very high temperature. As the reduced ore is gradually and constantly falling into the bath, and at a red heat itself, it is not difficult to keep up the temperature of the furnace and bath with a minimum of fuel.

METALLURGICAL PROGRESS

By PERCY LONGMUIR,

National Physical Laboratory.

Blast Furnace Practice.

Fundamental Principles Involved in Blast Furnace Practice.—In last month's issue, various aspects of dessicated air were shown, and it will be remembered that, on the whole, general opinion regarded the published economies as over-stated. Turning to a recent paper by Mr. E. A. Uehling,* we quote the following as representing a typical American opinion:—"In the author's estimation, dessication of the blast is a step in advance, second in importance only to the hot blast, and that it will be generally, and perhaps even more promptly, adopted." Leaving for the moment this question of dried or undried air, we find in Mr. Uehling's paper an admirable review of the fundamentals involved in the operation of a blast furnace.

Chemically, iron ore may be selected and mixed to produce the desired type of iron; but in regard to the physical condition of the ore, there is at best but a limited choice and frequently none whatever. The more refractory the ore, the finer it should be physically, to become readily reduced; but in nature these ores are generally found in compact masses, whilst the easily reducible ores are frequently found in a more or less finely comminated state. The logical corollary that, the finer the state of division, the greater the reducibility of the ore, whilst theoretically correct, does not hold good in the blast furnace; for the finer the ore, the greater the resistance offered to the ascending gases, and also the greater the quantity of dust carried into the flues. The worst possible ore mixture, from a physical point of view, is that in which the coarse and fine are so proportioned and so thoroughly mixed that the latter fills all the interstices between the former. A layer of such a mixture is less penetrable, offers greater resistance to the ascending gases, requires higher blast pressure, is apt to produce more flue dust, and is therefore less desirable than if it consisted of fine ore alone. This is true of all mixtures of irregular size, and the greater the difference between the coarse and fine the worse the result.

To the practical objections against the use of fine ore, viz., heavy blast pressures and reduced yield, should be added the difficulty of properly distributing the ore over the coke charge. Once this problem is solved, the author is of opinion that very fine ores could be smelted to best advantage by themselves in a specially-designed furnace.

Flux and Slag.—The function of the flux is to fuse with the earthy impurities of ore and fuel and form a liquid slag. The function of the latter is two-fold: physically, it acts as a filter through which the globules of iron pass, and as a blanket protecting the accumulated metal against oxidation by the blast; chemically, its most important functions are to absorb sulphur and to assist in regulating the silicon content of the iron.

Fuel.—Blast furnace fuel has a dual *rôle*. Its physical function consists in preserving a comparatively open stratification in the descending column, thereby permitting an easy upward flow of the ascending gases. For this purpose the coke should be coarse and rough, uniform in size, and free from dust. Its strength should be such as will permit it to reach the tuyeres with the least loss by abrasion. Chemical functions of the fuel are found in (1) the generation of the requisite heat, and (2) the production of the reducing gas necessary for the conversion of the ore to the metallic state.

Air represents the cheapest and most neglected of the raw materials. The author advocates far greater attention in this direction, especially in the way of "small things" such as leaks between piston and tuyeres, engine-room temperature, variable humidity, etc. Theoretically, the temperature limit of the blast is not reached until the fuel displaced has reduced the quantity to such an extent that the CO formed is insufficient to reduce the ores carried. A blast furnace cannot work on heat alone; a reducing

* Journal of the Franklin Institute, Feb., 1905.

atmosphere must be maintained, and sufficient solid fuel must be present to fulfil its physical function. Whilst there is a difference of opinion as to the most economical blast temperature, there is no such difference as to the value of a regular and readily controllable temperature.

Hanging.—Experiments have shown that certain ores become impregnated with carbon to such an extent as to considerably increase in volume, a feature to which hanging may be attributed, for it follows that this swelling must increase the resistance to the gaseous currents and must also increase the friction against the furnace walls. A portion of the column having once come to rest, it will remain so until the cause of arrest is removed.

Slipping.—Since no cold stock enters the furnace during the period of hanging, its temperature must increase; consequently, chemical action is accelerated. Carbon deposited at the lower temperature is consumed by the oxygen liberated from the ore which it had impregnated, or, by reducing CO_2 to CO, probably both. As this continues, the stationary column shrinks, gradually loses its hold on the walls, and finally breaks away. These "top slips" are chiefly familiar to one grade of ore, and, owing to their violence, are termed "Mesabi ore explosions."

Bottom Slipping occurs entirely within the zone of fusion, and is chiefly caused by temperature variations associated with irregularity in the composition of the slags. Basic slags are more inclined to build up than are acid ones. When the accumulations which give rise to bottom slips become chronic, "scaffolding" results. There can be no doubt that scaffolding starts in the zone of fusion, and is due to the causes that give rise to bottom slips. Whether these disturbances will ever be entirely overcome may be questioned; yet there is still room for improvement in furnace practice—*e.g.*, in the preparation of ore and flux, selection of fuel, method of charging, uniform blowing, dessication, and regular heating of blast, etc. These improvements, once effected, may eliminate many of the now familiar troubles.

Steel: Its Treatment and Properties.

The Comparative Hardness of Acid and Basic Open Hearth Steel at Various Temperatures.—Mr. J. A. Brinell* has investigated the influence of temperature on the hardness of steel, employing for this purpose two steels of similar analysis—one of acid and the other of basic manufacture. The analyses are as follows:—

	Carbon.	Silicon.	Manganese.	Sulphur.	Phosphorus.
Acid Steel ...	0·17	0·014	0·35	0·015	0.028
Basic „ ...	0·17	0·014	0·35	0·015	0·009

The testing operation consisted in forcing a 15 millimetre ball into each specimen at a uniform pressure of 2,000 kilogrammes. The comparative hardness results thus obtained are embodied in the following table:—

Testing Temperature.	Acid Steel Charge No. 5367.			Basic Steel Charge No. 4611.		
	Diameter of Impression.	Hardness Number.	Calc. Ultimate Stress	Diameter of Impression.	Hardness Number.	Calc. Ultimate Stress
0° C.	5·20	91·2	35·8	5·30	87·5	34·4
100° C.	5·20	91·2	35·8	5·35	85·8	33·6
200° C.	5·30	87·5	34·4	5·45	82·5	32·4
300° C.	4·80	107·5	42·2	5·10	95·0	37·3
400° C.	4·85	104·7	41·1	4·85	104·7	41·1
500° C.	4·95	100·5	39·5	5·10	95·0	37·3
600° C.	5·95	68·6	26·9	6·10	65·4	25·7
700° C.	8·15	35·2	13·8	8·40	33·0	12·9
800° C.	9·50	25·0	9·8	9·90	22·7	8·9
900° C.	10·15	21·4	8·4	10·40	20·2	7·9
1000° C.	11·15	17·1	6·7	11·50	15·8	6·2
1100° C.	12·80	11·8	4·6	12·85	11·6	4·5
1200° C	14·75	6·9	2·7	14·75	6·9	2·7

Ultimate stress is calculated from hardness results by multiplying the hardness number by 0.393, the relation between ultimate stress and hardness being assumed as constant, regardless of temperature. The compiler adds a footnote, stating that this coefficient (0.393) is as yet of a provisional character.

Sulphides and Silicates of Manganese in Steel.—In a recent issue of the *Iron and Steel Magazine*, Mr. J. E. Stead describes experiments which show the existence of silicates in steel. Bright pieces of steel were immersed in 10 per cent. nitric acid until the free acid was nearly saturated. The liquid was decanted off, and the slime adhering to the pieces washed into the beaker containing the insoluble residue. This residue was washed and dried, and had a pale green colour. Microscopical examination showed the particles to be ellipsoidal in shape. Analyses gave the following result:—

Protoxide of manganese ...	42·00%
Protoxide of iron	traces.
Silica	56·00%

giving an approximate chemical formula of $(MnO_2)\ (SiO_2)_3$. However, under differing conditions—such as composition, temperature, and size of casting—it is possible that the analysis of the silicate may vary considerably. The metallographic features of the silicate of manganese are indicated, and the importance of further investigation emphasized.

Iron and Steel Magazine, Vol. IX., No. 1.

Foundry Practice.

Core Sand Binders.—Mr. J. S. Robeson* justifies his title in that these materials are used solely for their adhesive properties. The binders in general use are as follows:—*Solid.*—Dextrine, flour, proprietary dry mixtures, and rosin. *Liquid.*—Fish oil, glue, gluetrin, linseed oil, molasses, proprietary oil mixtures, and rosin oil. These materials are examined at full length, and the conclusion is reached that liquid binders are the most serviceable.

Melting with the Air Furnace.—The better qualities of air furnace metal compared with that of the cupola are indicated by Dr. Moldenke in an issue of the *American Machinist*. For special castings where grey iron is preferable to steel, this furnace has long been in use, and many foundries are producing from it castings which approach a tensile strength of 40,000 lb. per sq. in. The chief difference between cupola and air furnace practice is that in the former the metal is in contact with the fuel during melting, whilst in the latter it is only touched by the flame. For high quality castings the air furnace is strongly advocated, and for the benefit of the machinery trade the author hopes to see its wider adoption.

Science in the Iron Foundry.—That a scientific control of the foundry pays is to some extent recognized, but many founders have yet to realize the actual value of such control. To those still in doubt, an address delivered to the Cleveland Institution of Engineers by Mr. J. E. Stead will prove of high value, and in it are to be found many valuable suggestions for the scientific operation of a foundry.

In the introductory portion, emphasis is laid on the variations in pig irons, for whilst mixtures of certain brands give at one time good results, they may at another time yield poor ones. In such a case, the founders experience is not at fault, the reason lying in the variable nature of the pig iron supplied to him. The variation can only be overcome by a full analytical control, which involves, in the first place, a conveniently arranged stock yard, and, in the second, representative sampling for analysis. If the consignment is regular, two pigs from each truck will give a fair average; but if of mixed quality, a larger number will be required. The best position for drilling is from the centre of one side, *i.e.*, midway between the top and bottom surfaces.

Turning to the effect of metalloids on cast iron, *silicon* is treated first, and experiments made by Mr. Stead in 1875 are described. The work of Wood, Turner, and Gautier in this direction is given, and the action of silicon on carbon is shown. The direct effect of *sulphur* in cast iron is regarded as injurious, though reliable data is scanty. Johnson and Keep have investigated this influence, and their results show that, provided the sulphur does not retard the separation of graphite, even 0.15 per cent. has little effect on the strength of the metal. In Johnson's trials, the only direct effect appeared to be that of making a closer grain, and consequently stronger casting. However, sulphur has an undoubted effect, for unless the silicon is fairly high, it prevents the separation of graphite, and a hard iron results. With over 0.5 per cent. of manganese, sulphur exists chiefly as sulphide of manganese. This sulphide separates before the metal becomes solid, and, owing to its low specific gravity, floats upwards, a feature which explains why pig irons contain more sulphur at the top than at the bottom. An important feature is that once this sulphide has independently separated, it no longer exerts an influence on the carbon condition.

Carbon.—The combined carbon is mainly the determining factor of the hardness and shrinkage of a casting, and for general engineering castings about 0.5 per cent. is a fair average content.

A high content of carbon in the graphitic state is objectionable, owing to the fact that each plate of graphite mechanically breaks the continuity of the metallic matrix, and the fewer of such breaks, within reasonable limits, the more coherent is the mass. The content of total carbon should therefore not exceed 3.25 per cent. If too high, it can be readily reduced by the careful addition of steel scrap to the cupola charge.

Manganese in British irons is higher than those of America; and Scotch irons, which are notably high, yield excellent results on this side. Manganese has a strengthening effect, and is of advantage by its influence on sulphur. Phosphorus exists in pig iron in the form of a phosphide of iron, Fe_3P. The amount this phosphide formed by a given content of phosphorus is as follows:—

0·5%	phosphorus equals	3·22%	Fe_3P
1·0%	,,	6·45%	,,
1·5%	,,	9·67%	,,

As the phosphorus increases, the relative mass of the eutectic containing the phosphide also proportionately increases. In proportion to this increase, the metallic matrix becomes weaker and weaker, the plane of fracture becomes more even, and the iron does not tear in breaking, but snaps suddenly. Phosphorus, unless present in high quantity, has no influence on the carbon condition, and it does not appear to influence the chill except perhaps to define the demarcation between the chilled and unchilled portion.

* Pittsburg Foundrymen's Association and *The Iron Trade Review*, Vol. XXXVIII., No. 6.

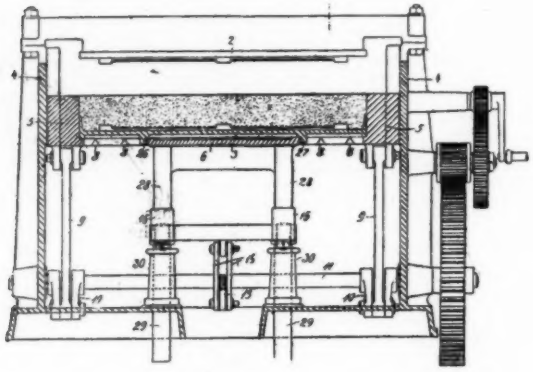


FIG. 1.

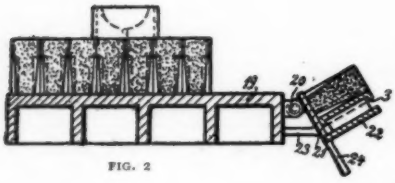


FIG. 2

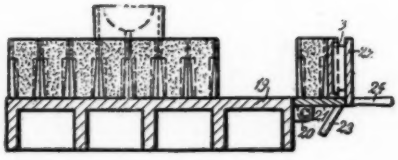


FIG. 3.

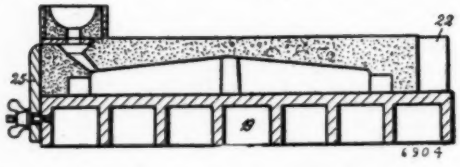


FIG. 4.

MOULDING MACHINE FOR GRATE BARS.

A Moulding Machine for Grate Bars.—This machine recently described by Mr. Fischer in *Giesserei Zeitung* is interesting in that it represents a method of making grate bars with chilled faces. Each mould receives a half-impression on two sides, and these sections placed together form a more or less continuous row of moulds. Several views of the machine are given, but that represented in Fig. 1 is sufficiently typical where the two half-pattern plates are shown at 2 and 3. The action of the machine is evident, and it will be noted that, on completion of ramming, a mould section containing two half grate bar impressions is obtained. Figs. 2 and 3 show the method of putting these sections together on a bottom plate, which serves as a chill. The section carried on the lower plate, 3, of Fig. 1, is placed as shown in Fig. 2, and the lever 24 raised to the position shown in Fig. 3, and the sections joined together. Fig. 4 shows the method of casting, with a guide, 25, for keeping the sections in their relative positions. The machine is of the twin type—that is, two sections are rammed at one time—and is patented by S. Michailow, of Odessa.

Continuous Process for Car Wheel Manufacture.—Continuous foundry methods have not yet reached a state of marked efficiency. However, we notice one, applicable to car wheels, described in the *Iron Trade Review*, which is stated to yield very good results. In the following, a brief *résumé* of the essential features is given. The plant consists of an endless track and mould conveyor, 100 ft. in diameter, having accommodation

for seventy-two moulding boxes (Fig. 1). Movement of the conveyor is intermittent, and the distance moved at one time is equal to the space occupied by one box. Ten patterns are employed, and each box receives its pattern at *A* (Fig. 3), as the box moves from point to point, sand is fed from overhead spouts, *H* (Fig 1), and each man does that portion of work assigned to him, which is always the same on each box. The moulds are closed at *F* (Fig. 1), and each box, as it leaves *B* (Fig. 3) is ready for pouring. Casting is effected from a bottom pouring ladle as the boxes pass the pouring crane *A* (Fig. 1). The wheels are stripped at a cherry red heat, near the annealing pits, *K* (Fig. 1). As the sand is removed it drops into the conveyor, *A*, (Fig. 4), and is automatically screened, mixed, and tempered whilst being conveyed to the moulding section. This plant has been introduced and put into successful operation by Mr. C. W. Sherman.

General Metallurgy.

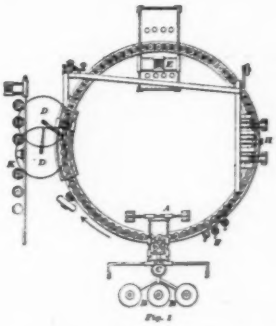
Pyrometer for the Measurement of High Temperatures.—The importance of temperature control in metallurgical operations is recognized. This control can only be obtained by accurate measurement; and, as Mr. Kuppers indicates in a recent issue of *Giesserei Zeitung*, not only is the temperature required, but in many cases a record of the full period of a furnace run is essential. One type of such a recorder is described which gives a continuous record of the temperature of thermo junction as functions of time in a co-ordinate system. This instrument, built by Siemens and Halske, is illustrated in Fig. 1. Leads from the thermo junction connect with the finger *A*, below which the paper strip *B* moves at a uniform speed in the direction indicated by the arrow. Above this finger is a curved bow, *C*, moving on the two points *E*. Under the paper strip *B* a colour band *D*, is arranged, which has a uniform movement across the strip *B*. The bow *C* at determined intervals is raised by the ratchet wheel, and on release strikes the finger *A*, thereby obtaining a mark from colour band *D* on to strip *B*. By arranging the speed of paper and the intervals between the blows, a practically continuous line may be obtained. Fig. 2 shows a temperature record obtained from this instrument.

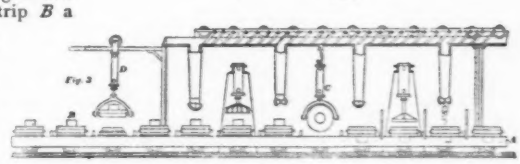
*Examination of Carbon Silicide in the Cañon Diablo Meteorite.**—Mr. Moissan, in continuing his examination of this meteorite, has detected crystals of a form identical with that of carbon silicide, SiC. The interesting feature is that this block of iron, whether of terrestrial or sidereal origin, by containing carbon silicide, shows that products only prepared at the temperature of the electric furnace are present in nature.

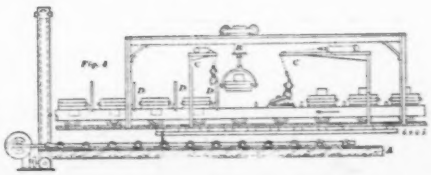
*Researches on Copper Alloys.**—In this memoir, communicated to the Societe d'Encouragement pour l'Industrie Nationale, M. Guillet deals chiefly with special brasses and the quenching of bronzes. The introductory portion contains a general review of the constitution and manufacture of ordinary brasses. Special brasses are defined as alloys of copper and zinc, containing, in addition, one or more elements added to obtain particular properties. Of these additions, lead, tin, aluminium, and manganese are studied. Ordinary brasses seldom consist purely of copper and zinc, but usually enclose from 0.5 to 3.10 per cent. of lead, and the well-known fact that this metal facilitates turning is emphasized. Micrographically, lead is found to split up the structure by diminishing the number and

* "Comptes Rendus," Vol. CXL., No. 7.

**Revue de Metallurgie*, Vol. 2, No. 2.







CONTINUOUS PROCESS FOR CAR WHEEL MANUFACTURE

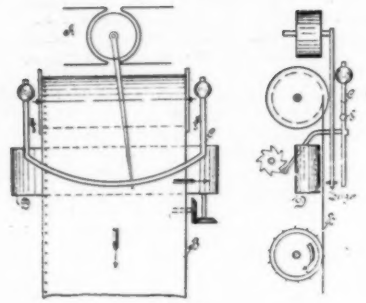


Fig. 1

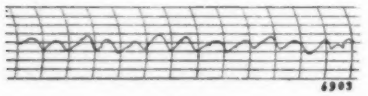


Fig. 2.

PYROMETER FOR THE MEASUREMENT OF HIGH TEMPERATURE.

importance of the large crystals. A limit to the addition of lead is found in brasses at a content of 5 per cent., beyond which distinct liquation is found, and such a product will, on hot-rolling, sweat or exude lead. The influence of lead on the mechanical properties is shown in the appended tables, from which it will be seen that the effect of an ascending content is to lower slighty elastic limit and tensile strength, to

FIRST ON BARS ROLLED, DRAWN AND ANNEALED

Composition.			Mechanical Properties.					
Cu.	Zn.	Pb.	Elastic limit Kilos per sq. mm.	Max Stress Kilos per sq. mm.	El. ngation %	Reduction of area.	Frémont drop test.	Hardness No. Brinell.
59·50	39·70	0·85	12·1	29·9	45·5	56·8	8	60
58·45	39·35	1·90	11·5	27·3	43·4	41·2	7	68
57·85	38·85	3·05	10·8	22·2	41·1	38·3	4	62
56·15	40·00	2·72	9·7	20·3	31·9	37·0	3	60
54·85	39·45	5·15	9·8	20·0	30·2	35·2	3	60

SECOND ON BARS CAST.

FIRST SERIES.

Composition.			Mechanical Properties.					
Cu.	Zn. by difference.	Pb.	Elastic Limit Kilos per sq. mm.	Max. Stress Kilos per sq. mm.	Elongation %	Reduction of area %	Frémont drop test.	Hardness No. Brinell.
60·0	40·0	0·0	8·1	31·9	47·0	59·6	12	56
59·5	40·0	0·5	8·3	32·1	33·5	33·0	7	57
59·0	39·8	1·2	8·3	27·9	14·9	18·5	6	52
60·1	37·2	2·1	8·1	30·2	12·5	16·0	6	59
53·9	39·1	3·0	9·8	29·2	12·5	10·0	5	69
SECOND SERIES.								
70·4	29·6	0·0	5·7	20·0	68	50	11	30·6
69·1	30·2	0·7	5·2	16·4	42	42	8	32·0
67·9	30·8	1·3	4·8	18·9	51	51	9	31·5
69·3	29·1	2·6	6·0	20·6	54	14	5	31
67·2	29·6	3·2	4·0	13·5	32	32	6	32

diminish elongation and contraction of area, whilst hardness is not appreciably affected.

Turning to the influence of tin, mechanical tests show it to slightly increase tensile strength; but when a contact of 1 per cent. is exceeded, a marked diminution of elongation and contraction of area occurs. Brasses containing tin as a special constituent are, owing to the resistance offered to corrosion by sea-water, used chiefly in naval construction. The composition of such brasses vary within the following limits:—Copper, 60 to 62 per cent.; tin, 1.0 to 1.5 per cent.; zinc, 37.0 to 39.0 per cent. The following table embodies the results obtained from the brasses containing tin:—

ON BARS ROLLED, DRAWN AND ANNEALED.

Composition.			Mechanical Properties.					
Cu.	Zn.	Sn.	Elastic limit Kilos per sq. mm.	Max Stress Kilos p r sq. mm.	Elongation %	Reduction of area %	Frémont drop test.	Hardne s No. Brinell.
59·42	39·67	0·72	11·3	34·0	40	49·5	13	67
59·35	38·89	1·29	12 5	34·3	35	39·2	7	74
60 03	37·62	2·22	14·2	35·9	13	12·7	0	77

To be continued.

In this section is presented every month a list of the principal contents of the leading organs of the technical press and of the proceedings of learned societies throughout Great Britain, the Continent, and America; and also, in a summarised form, the subject matter of the more important articles appearing therein.

The following is an alphabetically-arranged list of the publications regularly reviewed, together with the place of publication and price.

American Engineer and Railroad Journal, 140, *Nassau Street, New York*	20 cts.
American Machinery, 9-15, *Murray Street, New York*	20 cts.
American Machinist, 218, *William Street, New York*	4d.
Annales de l'Association des Ingenieurs sortie de Gand, *Rue Longue du Marais*, 15, *Ghent*	2 frs. 30 c.
Association of Engineering Societies, Philadelphia, *Philadelphia*	30 cts.
Australian Mining Standard, 31, *Queen Street, Melbourne*...	6d.
Automotor Journal, 44, *St. Martin's Lane, W.C.*	3d.
Beton und Eisen, *Kortorung*, 14, *Vienna I.* ...	2 marks
British Clayworker, 43, *Essex Street, W.C.* ...	6d.
Bulletin La Societe International des Electriciens, 12 & 14, *Rue de Stael, Paris* ...	2 fr 50 c.
Canadian Engineer, 62, *Church Street, Toronto*	10 cts.
Centralblatt für Accumulatoren, *Gross-Lichterfelde-West, Bellevuestrasse*, 40, *Berlin*, ...	3 mks. 50 pf. per qt.
Colliery Guardian, 30 & 31, *Furnival Street, Holborn, E.C.*	5d.
Compte Rendu des Travaux de la Societe des Ingenieures Civils de France. 9, *Rue Blanche, Paris*	—
Der Mechaniker, 113, *Potsdamerstrasse, Berlin, W.* 35	40 pf.
Dingler's Polytechnic Journal, *Berlin*	3 mos. 6 mrks.
L'Echo des Mines et de la Metallurgie, *Paris*	45 fr. p.a.
L'Eclairage Electrique, 40, *Rue des Ecolos, Paris*	1 fr. 50 c.
Electrical Engineer, 139, *Salisbury Court, E.C.*	3d.
Electrical Rev ew, N.Y., 41, *Park Row, New York, U.S.A.*	10 cts.
Electrical Times, 8, *Breams Buildings, Chancery Lane, E.C.*	2d.
Electrical World and Engineer, 120, *Liberty Street, New York*	10 cts.
The Electrician, 1/3, *Salisbury Court, E.C.* ...	6 1
L'Electricien, 18, *Rue des Fosses; St. Jacques, Paris*	50 cts.
Electricity, 36, *Maiden Lane, W.C.*	1d.
Electricity, 136, *Liberty Street, New York* ...	10 cts.
Der Electro Techniker, *Hengasse*, 62, *Vienna*	60 pfs.
Elektrische Bahnen U. Betriebe, 8, *Gluckstrasse, Munich*	16 mks. p.a.
Elektrotechnische Rundschau, *Herderstr*, 10a, *Dusseldorf*	6 mks. 6 mos.
Elektroteknisk Tids-krift, *Copenhagen* ...	12 öre
Elektroteknisk Tidskrift, *Christiania*	4 kr. for 6 mos.
Elektrotechnische Zeitschrift, *Monbiionplatz*, 3, *Berlin, N.* 24	70 pf.
L'Elettricista, *Via Cavour* 222/226, *Rome* ...	25 cts.
L'Elettricita, *Via Boccaccio*, 5, *Milan*	50 cents
La Energia Electrica, *Plaza de Isabel* 11, *num.* 5, *Madrid*	1 peseta
The Engineer, 33, *Norfolk Street, W.C.* ..	6d.
Engineering, 35/36, *Bedford Street, W.C.* ...	6d.
Engineering and Mining Journal, 253, *Broadway, New York*	5 dols. per ann.
Engineering Magazine, 222, *Strand, W C.* ...	1/-
Engineering News, 220, *Broadway, New York*	15 cts.
Engineering Record, 114, *Liberty Street, New York*	12 cts.
The Foundry, *Cleveland, Ohio, U.S.A.* ...	15 cts.
Gas World, 3, *Ludgate Circus Buildings, E.C.*	3d.
Le Gaz, 12, *Rue Fontaine, Paris*	1 fr.
Le Genie Civil, 6, *Rue de la Chaussee d'Antin, Paris*	1 fr.
Giesserei-Zeitung, *Jerusalemer Strasse*, 46/47, *Berlin, S.W.*	40 pf.
Gluckauf, *Essen A. D., Ruhr, Germany* ...	1 mk. 25
La Houille Blanche, *Grande-Rue*, 23, *Grenoble*	1 fr. 25 c.
Ice and Cold Storage, 89, *Farringdon St., E.C.*	6d.
L'Industrie Electrique	1 fr.
Iron Trade Review, *Cleveland, Ohio*	4 dols. 50 c. p.a.
Iron and Coal Trades' Review, 165, *Strand, W.C.*	6d.
Iron and Steel Magazine, 446, *Tremont Street, Boston*	50 cts.
Iron and Steel Trades' Journal, 4, *Suffolk Lane, Cannon Street, E.C.*	3d.
Journal American Society of Naval Engineers, *Washington*	5 dols. p.a.
Journal of the Association of Engineering Societies, *Philadelphia, Pa.*	—
Journal of the Chemical, Metallurgical and Mining Society, *Johannesburg, S.A.* ...	2/-
Journal of Gas Lighting, 11, *Bolt Court, Fleet Street, E.C.*	6d.
Journal of the Franklin Institute, *Philadelphia, U.S.A.*	30 cts.
Journal of the Institution of Electrical Engineers 92, *Victoria Street, S.W.* Single copies vary	1/6-7/6
Journal of the Iron and Steel Institute, 28, *Victoria Street, S.W.*	16/- per vol. 2 annually
Journal of the Society of Arts, *John Street, Adelphi, W.C.*	6d.
Journal of the Western Society of Engineers, *Chicago, U.S.A.*	50 cts.
Die Lokomotive, *IV. Muhlgasse*, 7, *Vienna* ...	40 h.
La Locomotion Automobile, 4, *Rue Chauveau Lagrande, Paris*	50 cts.
Light Railway and Tramway Journal, 16, *Eldon Street, E.C.*	1/-
Locomotive Engineering, 95, *Liberty Street, New York*...	—
La Machine, 11, *Rue de la Dole, Geneva* ...	4 frs. 6 mos.
Machinery, *New York*	25 cts.
Marine Engineer, 3, *Amen Corner, Paternoster Row, E.C.*	6d.
Marine Engineering, 309, *Broadway, New York*	20 cts.
Mechanical Engineer, 53, *New Bailey Street, Manchester*	6d.
Mechanical World, *New Bridge St., Strangeways, Manchester*	2d.
Die Metallurgie, *Ludwigsallee*, 15, *Aachen, Germany*	40 pfg.
Mines and Minerals, *Scranton, Pa., U.S.A.* ...	20 cts.
Mining World, 234/6, *Gresham St., Old Broad Street, E.C.*	6d.
Mining Magazine, 120, *Liberty St., New York*	20 cts.

Mettheilungen des Vereines für die Forderung des Local und Strassenbahnwesens, *Elisabethstrasse, Vienna*	—
Modern Machinery, 218, *La Salle St., Chicago*	10 cts.
Les Mois Scientifique, 8, *Rue Nouvelle, Paris*	1 fr. 50 c.
Nature, *St. Martin's Street, W.C.*	6d.
Physical Review. *Ithaca New York, U.S A.*	50 cts.
Power, *World Building, New York*	20 cts.
Practical Engineer, 287, *Deansgate, Manchester*	2d.
Proceedings of the American Society of Civil Engineers. 220, *West 57th Street, New York*	Mbrs. only
Proceedings of the Canadian Society of Civil Engineers, 112. *Mansfield Street, Montreal*	Mbrs. only
Proceedings of the Engineers' Club of Philadelphia, 1122, *Givard Street, Philadelphia*	2 dols. per vol.
Proceedings of the Engineers' Society of West Pennsylvania, *Pittsburg, Pa.*	50 cts.
Proceedings of the Faraday Society, 82, *Victoria Street, S.W.*	6d.
Proceedings of the Institution of Civil Engineers, *Great George Street, Westminster*...	Mbrs. only
Proceedings of the Institution of Mechanical Engineers, *Storey's Gate, Westminster* ...	Mbrs. only
Proceedings of the Royal Philosophical Society of Glasgow, *Glasgow*	10/6 p.a.
Public Health Engineer, 50/52, *Ludgate Hill, E.C.*	3d.
Public Works, 22, *Bride Lane, E.C.*	Qtly. 2/6
Quarry, 49, *Essex Street, W.C.*	6d.
The Railway Age, *Monadnock Block, Chicago*	10 cts.
The Railway and Engineering Review, 1305, *Manhattan Building, Chicago*	10 cts.
The Railway Master Mechanic, 269, *Dearborn Street, Chicago*	10 cts.
Railway News, 91. *Temple Chambers, E.C.* ...	6d.
Railway Official Gazette, 43, *Cardigan Street, N.W.*	1d.
La Revue de Metallurgie, 75, *Rue Notre Dame des Champs, Paris*	4 fr. 50 c.
La Revue Mineralurgique, 31, *Rue de la Victoire, Paris*	60 cents
La Revue Technique, *Paris*	1 fr.
School of Mines, Quarterly, *Columbia University, New York, U.S.A.*	50 cts.
Scientific American, 361, *Broadway, New York*	8 cts.
Stahl & Eisen, 5, *Jacobstrasse, Dusseldorf* ...	24 mks. p.a.
The Steamship, 2, *Custom House Chambers, Leith, N.B.*	6d.
Stevens' Institute Indicator, *Hoboken, N. Jersey*	50 cts.
Stone Trades' Journal, 36/38, *Southampton St., W.C.*	6d.
Street Railway Journal, 120, *Liberty Street, New York*	6d.
Street Railway Review, *Byron House*, 82, *Fleet Street, E.C.*	1/-
Surveyor, 24, *Bride Lane, E.C.*	3d.
Technics, 5/12, *Southampton St., Strand, W.C.*	9d.
Technology Quarterly, *Institute of Technology, Boston, Mass.*	75 cts.
Teknisk Tidskrift, *Stockholm*	—
Teknisk Ugeblad, *Prinsensgade 11, Christiania*	30 ore
Tramway and Railway World, *Amberley House, Norfolk Street, W.C.*	1/-
Transactions of the American Institution of Electrical Engineers, 26, *Cortlandt Street, New York*	Price varies
Transactions of the American Institution of Mining Engineers, 99, *John St., New York*	Price varies
Transactions of the American Society of Mechanical Engineers, 12, *West 31st Street, New York*	Mbrs. only
Transactions of the American Society of Naval Engineers, *New York*	5 dols. p.a.
Transactions of the Civil and Mechanical Engineers' Society, *Victoria Street, S.W.*	Mbrs. only
Transactions of the Engineers and Shipbuilders in Scotland, *Glasgow*	Price varies
Transactions of the Society of Engineers ...	Mbrs. only.
Transport and Railroad Gazette, *Queen Anne's Chambers, Broadway West, S.W.*	6d.
Western Electrician, *Chicago*	10 cts.
Zeitschrift des Oestereichischen Ingenieur und Architekten Vereins, 1, *Exchenbachgasse, Vienna* 9	70 h.
Zeitschrift des Vereins Deutscher Ingenieure, *Berlin*	1 m. 40 pf.
Zeitschrift für Elektrotechnik, 7, *Nibelungenstrasse, 7. Vienna*	20 kr. p.a.
Zeitschrift für Elektrochemie, *Halle A. S. Germany*	4 mks. per qtr.

CIVIL ENGINEERING.

Bridges.

The Erection of the Quebec Bridge. Engineering Record, 4th March, 1905.—This bridge, which is the longest span undertaken in any country, will cross the St. Lawrence River, eight miles west of Quebec, and is now in active course of construction. It is 2,800 ft. long between centres of anchorage piers, and its superstructure weighs about 40,000 tons. There are two 500-ft anchor arm spans and one 1,800-ft. cantilever span over the channel. The latter is composed of two 562½-ft. cantilever arms connected by a 675-ft. centre suspended span. The pin-connected trusses are continuous from the anchorages to the ends of the centre suspended span, 1,062½ ft.. and are 315 ft. deep on centres over the main piers, 98 ft. deep at the ends of the cantilever arms, and 130 ft. deep in the centre of the suspended span. Both top and bottom chords are parabolic curves throughout, and the lower chord has a minimum clearance of 150 ft. above high water for 1,200 ft. in the middle of the river The trusses are braced together with lateral diagonal systems in the planes of the roadway and of the top and bottom chords, and have transverse sway bracing between the vertical posts above and below the roadway, all the secondary members having rivetted connections.

The article outlines the general character of the main spans, giving their principal dimensions and sufficient information concerning the members and connections to make intelligible a description of the preliminary operations of the erection and the general methods employed and plant to be installed for the execution of one the most important engineering constructions and the largest of its class ever undertaken.

The Erection of Blackwell's Island Bridge. Engineering Record, 4th March, 1905.—The bridge to be built across East River will have five cantilever and anchor spans aggregating 3,724 ft. between anchorages, and including a channel span of 1,182 ft. It will contain about 54,000 cu. yds. of masonry and over 86,000,000 lb. of steel in the five main spans. Work on the substructure was commenced July 19, 1901, and was completed June 10, 1904. The contract for the superstracture was let in November, 1903.

The main spans are remarkable for their dimensions; for the omission of the centre connecting spans usually suspended from the ends of the cantilever arms; for the peculiar design of the main vertical posts, and for the use of eyebars of

extremely large proportions made with nickel-steel of an ultimate strength of 85,000 to 100,000 lb. per sq. in.

The superstructure has pin-connected trusses in vertical planes 60 ft. apart on centres, 185 ft. deep centre to centre of pins at the piers, and 135 ft. high in the clear above mean high water. It is 90 ft. wide over all and will carry two elevated railroad and four electric car tracks, two carriageways and two sidewalks, with an estimated capacity of 150,000,000 passengers a year in the elevated and surface cars.

The main span of this bridge will be much longer than any such in the world except the two 1,710-ft. spans of the Forth Bridge. The Brooklyn Bridge and the Williamsburg Bridge, New York, cross the same river within a few thousand feet of its site, and have spans of 1,595 ft. and 1,600 ft. respectively, but are of the suspension type with stiffening trusses. The Quebec bridge now being constructed across the St. Lawrence River will have an 1,800 ft. channel span, but will not have as large a capacity, nor will its members have as great maximum cross-sectional areas.

Neither the design nor the erection of this bridge is comparable with the Forth bridge, because the latter has inclined trusses with riveted connections, and the different main members, unlike those of the Blackwell's Island bridge, are made with tubular sections and were built up in place, large shops having been established at the site for the purpose and nearly all work and plant being special. In this bridge the members will be wholly completed at the shops with the ordinary plant. They will be erected, whole, and quickly connected to be self-supporting, by plant corresponding to that ordinarily used by the contractors for heavy bridge work, modified and developed as required for the increased dimensions and decreased clearances of this work.

The Largest Concrete-Steel Arch Bridge: the Grirenwald Bridge at Munich. Engineering News, 23rd February, 1905.—The bridge comprises two main spans, which are three-hinged arches, and a number of small girder spans, all of reinforced concrete. The roadway of the main spans and its supporting posts are of the same material. Thus the structure contains several distinct points of interest. But it should be expressly remarked that while the girder spans, the roadway and the roadway posts are true reinforced concrete, depending vitally upon the contained steel, on the other hand the main arches were designed on the basis of the strength of their concrete, without any calculated stressing in the steel. The steel was added merely as a security against tensile stresses that *might* arise by accident, though the arch was so planned that every conceivable loading is safely provided for in the concrete.

The bridge has two arched river spans, each 70 m. (230 ft.) in span and 12·8 m. (42 ft.) in rise, centre to centre of hinges, and five girder spans each 8·5 m (28 ft.) in the clear. Of the girder spans, four are on the left bank and one is on the right bank of the river. The roadway is 9·2 m. (30 ft.) wide overall, containing a roadway 5 m. wide and two sidewalks each 1·5 m. wide in the clear. The arches themselves are 8 m. (26 2 ft.) wide. The total length of the bridge is about 2:0 m. (720 ft.)

The structure is a highway bridge, and was designed for a live load of 82 lbs. per sq. ft. uniform, and a 22-ton steam road roller. It will be appreciated that in spite of the extreme lightness of the structure, the live load is small compared with the dead load, and the small thickness of the arch ring, and the lightness of the whole construction, as they define results which have barely been reached with stone.

The "open spandrel" style of construction was adopted to reduce the dead load as much as possible. In large arches the dead load is so great a part of the total load that it virtually determines the required section of arch ring. Moreover, for the same reason the stiffening effect of solid spandrels is of little importance in large arches. On both grounds the "open spandrel" construction was called for, and in the structure as built this style is carried to its extreme possibilities by subdividing the usual transverse walls into independent posts, on which rest the roadway platform. There are five lines of these posts in the width of 8 m., that is, they are spaced 2 m, apart transversely; longitudinally the posts are 4 m. apart.

Improved Detail for Lateral Connections. Engineering Record, 11th February, 1905. — Riveted trusses for the Erie R. R. Co. have for some years been made with transverse diaphragms stiffening the lower chords at panel points and projecting some distance above them, so as to develop great transverse stiffness in the jaw-plates and prevent shearing stresses in them in a horizontal line at the upper edge of the lower chord.

In this construction the floor-beams are field-riveted to the inside gusset plates with their top flanges flush with the bottom flanges of the lower chords. The plates to which they are riveted, and corresponding plates on the opposite web of the bottom chords, are connected by vertical transverse diaphragms which extend beyond the top flange of the bottom chord to the upper edges of the connection plates, thus affording undiminished stiffness for any transverse stresses brought down by the diagonal members and transmitted to the lower lateral system through the plates. This improvement has been developed in accordance with a constant observation of old bridges and the examination of the effects of loading and service with a determined effort to exercise as much care with lateral as with vertical stresses.

Construction of the Passy Bridge and Viaduct, Paris Metropolitan Railway. Engineer, 10th March, 1905.

Types and Details of Bridge Construction: Plate Girders. F. W. Skinner. *Engineering Record*, 18th February, 1905.

A Three-Hinged Concrete Steel Arch. L. A. Keith. *Engineering Record*, 18th February, 1905.

The Moline Bridge. Engineering Record, 11th February, 1905.—The bridge is somewhat remarkable on account of the proportions and arrangements of the trusses. These are in four spans with three river piers. The bridge consists of two main side spans, which are made continuous with two-panel cantilever arms projecting beyond the river piers to carry a suspended centre span. The river ends of these spans are supported on rocker bents, and their parallel top and bottom chords are inclined to the horizontal to nearly correspond with the 6 per cent. grade of the floor platform. This platform is carried practically midway between the top and bottom chords up to the ends o

the cantilever arms. At this point it is united by flat vertical curves with the horizontal floor carried by the suspended centre span which has horizontal top and bottom chords.

At one end of the bridge an additional shore span of 124 ft. is built with inclined chords, and the river ends of the trusses are elevated on a rocker bent so as to keep the floor system close to the lower chord and still maintain it in the line of the middle adjacent trusses. This arrangement of trusses produces an unusual effect in the side elevation of the bridge, and serves to secure a maximum centre headway with a minimum elevation at the abutments, and with more simplicity and regularity of detail, and therefore more economy in the superstructure than is usually secured for spans of such character.

The Computation of Stresses in the Blackwell's Island Bridge. R. C. Strachan. *Engineering News*, 16th February, 1905.—There are many points of interest in the design of this bridge, and some of them are points on which there are strong differences of opinion between engineers.

The description of the stress analysis given in the article will doubtless arouse much interest among bridge engineers.

La Suppression du Bois dans les Tabliers des Ponts Suspendus Modernes. Genie Civil, 18th February, 1905.

Reinforced Concrete Floor for Deck Girders. Transport and Railroad Gazette, 17th February, 1905.

Canals, Rivers and Harbours.

The Panama Canal: Report of the Engineering Committee, Isthmian Canal Commission Engineering Record, 4th March, 1905.—The admirable report of the engineering committee of the Isthmian Canal Commission, which is printed in full, is one of those important documents that every engineer should read and consider. It explains those features of the canal problem which have been under investigation, and makes clear the great detail of some of the investigations which were needed before any plan for this great work could be drawn up in the way it should be.

The feature of the report which deserves careful attention is the recommendation for a sea-level canal. This project has everything to recommend it in view of the low cost at which excavation can be carried on at the Isthmus. If a sea-level canal can be constructed at the figure stated, it offers great advantages, which do not depend solely on the increased navigability of a tidal canal. The leading merit of such a project lies in the practicability of deepening and widening the canal whenever it should become necessary. The improvement of a lock canal in this way is very difficult, while in the case of a tidal canal the difficulties disappear.

Sand Pump Dredging on the Mersey. Engineering, 10th March, 1905.

Wave Action in Relation to Engineering Structures, D. D. Gaillard. *Engineering News*, 23rd February, 1905.—An abbreviation of a paper read before the U.S.A. Corps of Engineers, and deals with a number of observations made by the author (*a*) on wave force by means of a special form of dynamometer, (*b*) on the effects of wave action.

The Panama Canal: No. I. Engineer, 3rd March, 1905.

Rolling Dams at Schweinfurt, Bavaria. Engineering News, 19th January, 1905.

Irrigation.

Grouted Rubble Core Walls for the Weirs of the Delta Barrage, Egypt. Engineering News, 9th February, 1905.

Miscellaneous.

The Simplon Tunnel: No. I. Engineer, 3rd March, 1905.

Broken Stone Roads. R. Ryves. *Engineering*, 17th February, 1905.

Projet de Tunnel Tubulaire en Béton Armé. M. Paul. Piketty. *Genie Civil*, 28th January, 1905.

BUILDING.

Construction and Design.

Reinforced Concrete Machine Shop. Engineering Record, 4th February, 1905.

Reinforced Concrete. R. A. Cummings. *Proceedings Engineers' Society, Western Pensylvania*, Vol. XX., No. 12.

Concrete-Steel Construction in England. W. N. Twelvetrees, M.I.Mech.E. Beton-u.-Eisen: February, 1905.

Schornsteinbauten aus armiertem Beton in Nordamerika. Beton-u.-Eisen: February, 1905.

De l'utilité des barres de compression dans les dalles, poutres et combinaisons de dalles et des poutres, soumises à la flexion. N. de Tedesco. Beton-u.-Eison: February, 1905.

Die Querschnittsbestimmung von Platten und Plattenbalken aus Eisenbeton nach Wirtschaftlichen Gesichtspunkten. E. Elwitz. Beton-u.-Eisen: February, 1905.

Pali tubolari in cemento armato. L'Elettricita, 17th February, 1905.

Safeguards for Laying Concrete in Frosty Weather. Engineering Record, 4th March, 1905.

Diamond Bank Building, Pittsburg. Engineering Record, 18th February, 1905.—This building involved special features in the steel construction for the substructure. The street is sometimes flooded by extreme high water in the river, and provision has been made to resist a maximum head of 20 ft. for the basement and vault retaining walls, and for the upward pressure on the basement floor.

Heating and Ventilation.

Air Purification in the Ventilating Plant of the City Hall, St. Louis Engineering Record, 18th

Economies obtainable by Various Uses of Steam in a Combined Power and Heating Plant. Engineering Record, 18th February, 1905.

Vacuum System of Heating. W. Kavanagh *The Engineer* (U.S.A.), 1st February, 1905.

A Study for a Central Power and Heating Plant at Washington. Engineering Record, 11th February, 1905.

MATERIALS.

The Efficiency of Waste Gas Boilers in connection with Rotary Cement Kilns. By A. B. Helbig. *Engineering News.* February 16th, 1905.—It is well known to everyone connected with a cement mill that the fuel bill is one of the largest items of cost in the manufacture of Portland cement. Efforts to reduce this item have naturally increased as the market price of cement has decreased. So far, two methods have been suggested for reducing the amount of fuel consumed per barrel of cement manufactured. One is to increase the length of the rotary kilns and the other is to utilize the heat of the waste gases to generate steam for power. Lengthening of the kiln is certain to increase the output up to a certain ratio between the diameter of the kiln and its length, and it is usually only a question of cost and very often also of room in the old mills whether or not the kilns shall be lengthened. The author does not believe that new kilns shorter than 100 ft. will be installed in the future. Thermally, however, a 60-ft. kiln, with a waste gas boiler, is just as efficient as any longer kiln, and the object of the paper is to prove that the waste gas boiler alone solves conclusively the fuel problem of the cement mill.

Modern Manufacture of Portland Cement and Practical Testing Thereof. By H. K. G. Bamber. *British Clay-Worker.* February 15th, 1905.

Impact Testing of Notched Bars. M. C. Charpy. *Engineer,* March 10th, 1905.—An interesting paper read at a recent meeting of the Society of Civil Engineers of France. The author described a machine for this purpose in 1901, but since then its details have been greatly improved. The object of the apparatus is to allow a weight to fall upon a test bar, and to determine numerically the work that is done in breaking the bar. After an exhaustive series of trials the author has decided upon two types of machine, a large and a small one, and these he considers will meet the requirements of all practical cases.

Momentary Stresses in Metals. Engineer, March 3rd., 1905.—In this article the writer reviews and criticises the important results obtained by Mr. Bertram Hopkinson, M.A., in his investigations on the effect of a blow delivered by a falling weight on the end of a long suspended wire and described by him in a recent paper before the Royal Society.

The means of measurement was an ingenious ballistic extensionometer which registered the shock set up by the fall of a steel cylinder, weighing 1 lb., on a wire 20 ft. long hung against a wall. The wire was fixed at the top and carried at the bottom a small stop against which the cylinder fell. The general results obtained were that iron and copper wires may be stressed much beyond the static elastic limit and even beyond their static breaking loads, without the proportionality of stresses and strains being substantially departed from, provided that the time during which the stress exceeds the elastic limit is of the order of 1/1000 sec. or less. These results were fully confirmed by a large number of experiments in which different steady tensions were applied. The general conclusion is that in this material, which has an elastic limit of 40,000 lb., or 17·8 tons per square inch, and breaks at 28·5 tons, a stress momentarily exceeding 75,000 lb. or 33½ tons, and exceeding the static elastic limit for a time of the order of 1/1000 sec., may be applied without any very great failure of elasticity. It may be further noted that a blow from a height of 10 ft., giving a tension momentarily exceeding 900 lb., produces a permanent extension of one-three thousand five hundredth part or one-thirtieth of the ultimate extension caused by a steady load of 700 lb.

MECHANICAL ENGINEERING.

Boilers, Furnaces and Fuel.

Combustion. C. C. Major. *Power,* February, 1905.

Engines and Motors.

Calculating the Mechanical Efficiency and Output of Gas Engines By A. Riedler, Zeitschrift des Vereines Deutscher Ingenieure, Vol. 49, No. 8. February 25th, 1905. The mechanical efficiency of gas engines has so far been calculated in exactly the same way as in the case of steam engines. Prof. E Meyer first proposed a different practice in the case of two-cycle engines, deducting the charging work from the indicated output of the working cylinder.

On account of the criticism and discussion aroused by this suggestion, the author endeavours to elucidate the question as to how the efficiency of gas engines should be estimated, the more so as the Association of German Engineers is considering at the present time the establishment of guiding rules for the investigation of gas engines.

The calculation suggested by Meyer is based on the following hypothesis: "The indicated output N_i of a two-cycle engine is given by the difference between the output N_{i+} of the working cylinder and the consumption N_e and N_g of the charging pumps, thus: $N_i = N_{i+} - N_e - N_g$." That is to say: From the indicator diagram of two-cycle engines should be deducted the work of the special air and gas pumps as indicated independently.

There is further made the following assertion: The mechanical efficiency having to afford a measure of the proper friction resistance of the engine, should be put in the case of a gas-blowing machine $\frac{N_w}{N_{i+} - N_e - N_g}$, if the indicated blow-blowing work be N_w.

The author states that this calculation disagrees with the universally adopted notions of expended work, engine resistance and loss, while establishing some new notions which so far had no currency.

The difference stated by Meyer between the indicated output of an engine and the indicated output of the working cylinders has never been established before. The opinion that the mechanical efficiency is a measure of the proper friction of an engine, while not being incorrect, has long been superseded by the modern rule according to which the mechanical efficiency is the ratio of the effective work to the indicat d work—that is to say, the ratio between the gain of work and the expenditure of work. The mechanical efficiency, so far from being a measure of the frictional resistance of the engine alone, determines any resistances and losses obtaining, inclusive of the friction losses. To appreciate the economical value of an engine as a whole, the total losses, that is the aggregate resistance of the engine in all its parts, should be considered

The statement of Prof. Meyer that the consumption of air and gas pumps should be deducted

also in the case of the two-cycle engine is, in the opinion of the author, quite inadmissible. In calculating the four-cycle diagrams, the charging work is deducted by considering the indicated work of an engine (as usual in the case of steam engines) as the positive work expended in the cylinder during a complete run of the piston corresponding to the working cycle (this work being supplied to the piston) minus the negative work in the cylinder. Both of these are registered by the indicator immediately on the working cylinder as a closed curve and measured in some way or other. The charging work of the four-cycle engine is considered as negative work.

In the case of a two-cycle engine, however, the advantages are secured merely by special charging pumps, as in the case of steam engines, the advantages of vacuum are obtained only through the expenditure entailed by condenser pumps. It is quite inadmissible to leave this additional expenditure out of account in ascertaining the indicated output. As with model four-cycle engines the charging work is about 4 per cent. of the indicated full output, which, amounting with two-cycle engines to about 15 per cent. and even up to 50 per cent and more of the indicated output of the working cylinder, this deduction of 15 to 50 per cent. must of necessity exert a great and unreliable bearing on the figures found.

The Compound Steam-Turbine. Engineering, February 3, 1905.

The Keir Compound Steam Turbine. Power, February, 1905.

Making a Small Curtis Turbine. H. J. Travis. *Power.* February, 1905.

Power Required for Condensing Auxiliaries in a Steam Turbine Plant. J. R. Bibbins. *Power*, February, 1905.

The Lindmark Steam Turbine. Machinery, February, 1905.

Multiple Steam Turbines. A. Melencovitch. *Mechanical World*, February 24th, and March 3rd., 1905.

La Turbine à Vapeur de l'Allgemeine Eleks. Gesellft. Gen. Civ. March 4th, 1905.

Compound Corliss Spinning Mill Engine.—Engineer, 3rd March, 1905.

Corliss Engine Design III. L. L. Willard. *Engineer (Chicago)*, 1st March, 1905.

The Best Economy of the Piston Steam Engine at the advent of the Steam Turbine. Prof. J. E. Denton. *Engineering Record*, 25th February, 1905.

Recent Progress in German Gas Engines. Prof. Meyer. *Iron and Coal Trades Review*, 17th February, 1905.

Modern Large Gas Engines. H. L. Woolfenden. *Western Electrician*, 25th February, 1905.

Gas Engine Economy IV. C. E. Lucke. *Engineer (Chicago)*, 1st March, 1905.

Location of Feed-Water Heaters and Feed Pipes. The Engineer, 15th February, 1905.

Power and Transmission.

Injectors and Pumps The Engineer, March, 1905.—The article directs attention to points which have been missed in the discussion relating to injectors and pumps that has been proceeding in the columns of our contemporary. A certain correspondent, it appears, adopted a rather unusual method of ascertaining the thermal efficiency of injector and pump. A given quantity of water was sent in by the injector, and to restore the original conditions to raise it to the required temperature, and the steam to the required pressure, 294 lbs. of coal were required. Almost precisely the same quantity of water was then put in by a pump, and 367 lbs. of coal were used. With the injector the temperature of the feed was 160 deg, Fah., with the pump it was 60 deg. At first sight it is not easy to see why the pump used more steam than the injector. One explanation offered was that the cold water sent in by the pump lay at the bottom of the boiler, and so in effect the steam pressure was restored, although the whole mass of water in the boiler was still several degrees too low in temperature. Our contemporary is by no means certain that this explanation is entirely satisfactory. Taking the figures as they stand, the pump used more fuel than the injector in doing the same work by about 73 lb. The direct work of forcing the water into the boiler represented a little over one indicated horse-power, which would suffice to pump 1,710 gallons of water in sixty minutes against a head of 52 lb. on the square inch. This is quite an insignificant quantity, and was approximately the same for the injector. The true point at issue is, of course, the quantity of steam which the pump or the injector will require to do their work; and it is impossible to learn what this was from the information supplied. The whole of the steam withdrawn from the boiler by the injector was returned to the boiler as water, while that taken by the steam pump was wasted. The correspondent referred to mixes up the quantity of fuel necessary to heat the feed-water with that required to work the steam pump and the injector, and it is not supposed that the makers of steam pumps will accept the statement that the injector is more economical than the pump by some 16 per cent. as being the last word that can be said on the question.

Patent Turbo High-Pressure Pumps by Messrs. Escher Wyss & Co. Practical Engineer, 10th March, 1905.

The Transmission of Power by means of Link Belts. A. B. Morrison. *Engineer* (Chicago), 1st March, 1905.

Roller Chain Power Transmission and Construction of Sprockets. Machinery, February, 1905,

Bigue Flottante du Port de Riga. Genie Civil 28th January, 1905.

Hydraulics.

The Governing of Impulse Wheels. J. P. Church. Further discussion of Professor Goodman's article in *Engineering*, 4th November, 1904. *Engineering Record*, 25th February, 1905.

Les Forces Motrices des Lacs de Joux et de L'Orbe (Suisse). C. H. Perrin. *Genie Civil*, 25th March, 1905.

Les Moulinets comme moyens d'étudier le regime des cours d'ea et leur emploi dans la Solution des Problèms Hydrotechniques. W. Czarnomski. *Annuel de l'Association des Ingeneurs de Gand*, Vol. III., 1904.

Compressed Air.

Ignitions and Explosions in the Discharge Pipes of Air Compressors. A. M. Gow. *Engineering News*, 2nd March, 1905.—This valuable article relates to explosions in and about air compressors. That such explosions occur is known to a comparatively small percentage of those who are responsible for the care and operation of air compressors; and very little has been known concerning the causes of these explosions or the precautions which should be taken to prevent them. This paper is the result of an extensive investigation undertaken for a large mining company whose president desired to ascertain what precautions should be taken to guard against accidents in the operation of his company's air compressors.

Shop Equipment and Practice.

Roll Turning. W. S. Standfocd. *Am. Machinist*, 11th February, 1905.

Thread Tools, and Gauges. A. Norman. *Am. Machinist* 25th February, 1905.

Tool Grinders. T. S. Bentley, Am. I. Mech. Engineer, February, 1905.

Lathes for Rotors of Large Steam Turbines, constructed by Thos. Shanks & Co., Ldn. Engineering, 10th March, 1905.

The Brandt Hydraulic Rock Drill. Engineering, 24th February, 1905.

Miscellaneous.

The Strength of Gear Teeth sustaining Shock. Am. Machinist. 4th March, 1905.

The Theory of the Flow of Elastic Fluids and the Divergent Nozzle. M. Bluden. *Engineer.* 7th and 24th, 1905.

Calculators for the Velocity of Discharge of Fluid, from Pipes. Journal Gas Lighting, 21st February, 1905.

The Kinetic Theory of Gases and the Steam Turbine. Electrical Review. 10th March, 1905.

The Purification of Waste Lubricating Oil. F. H. Davies. *Contract Journal*, 1st February, 1905.

RAILWAY ENGINEERING.

Motive Power and Equipment.

Compound Locomotives in England. Transpt. and Rlrd. Gaz., 10th March, 1905.

There is every indication that the compound locomotive is at last to be given a thorough trial on English railways. By early summer compound locomotives will be experimentally introduced on two more of our trunk lines. On the Great Central and Great Northern Railways the engines will be of a type which, although not new in wheel arrangement, is nevertheless to mark a new departure in the locomotive practice on these lines.

The Great Central engine will be precisely similar to the existing 4-4-2 (Atlantic) type locomotives, except that it will have a third cylinder between the frames driving the crank axle of the first pair of coupled wheels; the outside cylinders driving the second pair as at present. The inside cylinder will be high pressure, and the outside cylinders low pressure. The method of working will be similar to that used in the Smith system of compounding on the Midland.

The Great Northern engine is to be compounded on the De Glehn system, with four cylinders (two pairs) driving different coupled axles. This locomotive is at present being built at the Vulcan Foundry Company's Works, Newton-le-Willows, Lancs.

Two further De Glehn Atlantics are nearing completion at Belfort, France, for the Great Western.

Compound 8-Coupled Goods Engine, with Leading Radial Axle, L. & N.W. Railway. Railway Engineer, March, 1905.

Six-Coupled Tank Engine for Japan. N.B. Locomotive Co., Ltd., Glasgow, Engineer, 10th March, 1905.

Italian Compound Express Locomotive for the Adriatic Lines. Railway Age, February, 1905.

Tank Locomotives for Suburban Service on American Railways. Engineering News, 16th February, 1905.

Cole's Radial Locomotive Trailing Truck. Transport, 3rd February, 1905.

4-6-0 Gekuppelte-Vierzylinder-Verbund-Shnellzug-Lokomotive der Paris-Lyon Mittelmeerbahn. Die Lokomotive, February, 1905.

Mechanische Beschickvorrichtungen für Lokomotiv" feuerbüchsen. T. Steffan. *Die Locomotive'* February, 1905.

Neuere Tender der Oester. Staatsbahnen. Die Lokomotive, February, 1905.

Six-coupled Tank Locomotive, Furness Railway. Engineering, 3rd March, 1905.

Steam Motor Carriages (1) *South-Eastern and Chatham Railway* (2) *Great Central Railway. Railway Engineer*, March 1905.

Steam Motor Coach, Furness Railway. Transport, February, 1905.

The Modern Railway Wagon. Geo. Willans. *Practical Engineering*, 24th February, 1905.

High Capacity Freight Wagons for the Madras Railway. Iron and Coal Trades' Review, February 24th, 1905.

Light Railway Goods Cars for the Argentine. Tramway and Railway World, 9th March, 1905.

40 tons Cantilever Coal Wagons, Great Central Railway. Railway Engineer, March, 1905.

New High Capacity Goods and Mineral Wagons on the Natal Government Railways. Iron and Coal Trades Review, 10th March, 1905.

New Steel Cars for the Metropolitan Side Elevated Railroad, Chicago. Railway Age, 3rd March, 1905.

Wagons à déchargement automatique Système Talbot.—These wagons are extensively employed in Germany and Belgium, and trials have recently been made with them in Paris. They are of the hopper type and discharge laterally. *Gen. Civil*, 4th March.

Proposed Specifications for Cast Iron Wheels, Transport and Railroad Gazette. C. W. Gennot, February 24th, 1905.

Forsyth Automatic Drain Pipe Coupler. Railway Age, 20th January, 1905.

Device for Regulating the Breaking Power of Cars. Railway Master Mechanic, February, 1904.

Permanent Way and Fixtures.

German Anti-Creeping Rail Anchor.—Description of a device applied to German roads between Aix-la-Chapelle and Dusseldorf, and between Cologne and Herbesthal with great success. *Railway and Engineering Review*, 18th February, 1905.

Rails for Lines with Fast Trains. Transport and Railroad Gazette, 10th March, 1905.

Track Laying on the Williamsburg Bridge. Engineering Record, 4th March, 1905.

Interlocking Plant of the Metropolitan Elevated Railway, Chicago. Railway Age, January 13th, 1905.

New System of All-Electric Interlocking.—Description of a new system now being installed on the Lake Shore and Michigan Southern Railway. *Railway and Engineering Review*, February 18th, 1905.

Ties and Tie Preservation. J. W. Kendrick — Abstract Report, International Railway Congress. May, 1905. *Railway Age*, 3rd February, 1905.

Rails for Fast Trains: Abstract of Report to be presented to the International Railway Congress, May, 1905. P. H. Dudley. *Transport and Railroad Gazette*, 24th February, 1905.

Miscellaneous.

Hydraulic Shearing Press for Coupler Pockets. American Engineer and Railway Journal, March, 1905.

The Cost of Locomotive Operation. G. R. Henderson. *Transport and Railroad Gazette*, 3rd March, 1905.

Automatic Couplers in Europe: Report of International Railway Congress to be held in May, 1905. *Transport and Railroad Gazette*, 3rd March, 1905.

The Care of Locomotive Boilers. M. E. Wells. *Railway Age*, 13th-20th January, 1905.

Block Signalling on Lines of Light Traffic. Transport and Railroad Gazette, 24th February, 1905.

Maintaining Railroad Repair Shop Machinery. Railway and Engineering Review, 11th February, 1905.

Recording Air-Brake Operations.—Description of a special car fitted out for obtaining data as to the operation of air brakes on passenger trains under various conditions. A new feature is the employment of shock meters for recording all shocks incidental to train handling and for recording the sway and rocking motion of the car. *Railway Age*, 17th February, 1905.

Notes on Old Railway Bridges. Railway Engineer, March, 1905.

Filing and Indexing Tracings of Railway Bridges. Description of system employed in the office of the bridge engineer of the Erie R. R. Co., N.Y. *Engineering Record*, 18th February, 1905.

ROAD TRACTION.

Steel as Applied to Motor Car Construction. J. S. Critchley, M.I.Mech.E. *Automotor Journal*, 25th February and 11th March, 1905.—The author passes in review the varying properties of steel. nd deals with the service and history of steel making, and in the course of his paper states that the motor industry undoubtedly calls for special reserches on the part of the metallurgist. No piece of machinery is more complex. When one looks at the specification of a motor car, it will be found that almost every known art or craft is involved in its construction, and of all these none is more important than the foundation of which it is built—namely, steel.

When one considers that 90 or more horse-power can be put into a vehicle with a total weight of under one ton, and capable of attaining a speed of over 90 miles an hour, one at once understands that it can only be done by the use of materials which, for ordinary engineering practice, would never be even suggested.

A new steel for gears, which has just been put in the market, is a French invention, the sole rights for France having been taken up by one of the largest builders of motor cars in Paris. This steel is carburised in the usual way by heating in boxes with the usual case-hardening substance, the time required being about seven hours, at the usual temperature of about 1,470 deg. Fah. The parts are, however, not quenched, but allowed to cool gently, when they become quite hard. As it is not necessary to quench in water the parts are not distorted. However, the most remarkable characteristic of this steel is that, as it is subjected to strain and friction, the harder and tougher it becomes. The physical tests of this steel are as follows:—Tensile strength, 33·4 tons per square inch; elastic limit, 24·8 tons per square inch; elongation in 2 in., 31 per cent.; and contraction of area, 69·5 per cent.

Recent developments which have been carried out by Mr. Kent Smith, the inventor, of a new process for producing vanadium steel at the works of Messrs. Willans and Robinson, Queensferry, have produced some excellent results, and the steel would appear to have exceptionally good qualities. The percentage of elastic limit to ultimate stress is generally high, and the ductility, as shown by the percentage of elongation, is superior to any steel of equal tensile strength. The impact and bending tests of this steel are excellent—in fact, they are superior to a 30-ton mild forging steel of good quality.

This steel can be made in an open hearth, it will weld, and is certainly not so delicate as regards heat treatment as are many high-grade steels.

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Variable Motor Cycle Gear: Paper by Prof. Callender before the Auto-Cycle Club. *Automotor Journal*, 11th March, 1905.

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Les Accouplements Articulés. La Locomotion Automobile, 2nd and 9th March, 1905.

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Les Progrès de l'Automobilisme en 1904. F.

Drouin. *Genie Civ.*, 28th January, 4th, 11th, and 18th February.

Le Frein Moteur Sauver, La Locomotion Automobile, 23rd February, 1905.

20-*H.p. Brotherton Petrol Car. Automotor Journal*, 18th and 25th February, 1905.

Motor Fuels. Dr. Ormondy. *Automotor Journal* 18th February, 1905.

Variable Motor Cycle Gear. Prof. Clalender. *Automotor Journal*, 18th and 25th February, 1905.

20-*H.p. Brotherhood Crocker Motor Car. Engineering*, 3rd Februarv, 1905.

40*ft. Motor Torpedo Launch. Engineering*, 3rd February, 1905.

ELECTRICAL ENGINEERING.

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The Nernst Lamp. E. R. Roberts. *Proceedings Engineers Society, West Pennsylvania*, Vol. XX., No. 2.

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Commercial Possibilities of Blast Furnace Gas for the Development of Electric Power. Electro Chemical Industry, March, 1905.

Electrical Plant of the Brooklyn Eagle. Western Electrician, 14th January, 1905.

Dampers for Synchronous Machines. E. L. Wilder. *Western Electrician*, 14th January, 1905.

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The Electric Drive. E. L. Walker. *Proceedings Engineers' Club, Philadelphia.* January, 1905.

Effect of Load Factor on Cost of Power. E. M. Archibald, B.Sc. *Proceedings Canadian Society of Civil Engineers, Engineering News*, 16th February 1905.

Electrically Driven Flour Mill. Engineering Record, 11th February, 1905.

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Some Tests as to use of the Synchronous Motor in compensating for Lagging Currents in a Circuit. Electric Review (N.Y.), 25th February. 1905.

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A Practical Vector-Diagram for Induction Motors. H. C. Specht. *Electrical World and Engineer.* 25th February, 1905.

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The Development of the Torpedo Boat Destroyer. W. J. Harding. Paper before the Institute of Marine Engineers, 13th March, 1905.

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The Screw Propeller. R. de Villamil. *Engineer*, 3rd and 10th March, 1905.

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The Design and Making of Sails. Adrian Wilson. *Marine Engineering*, March, 1905.

New Ferry-boats for San Francisco Harbour. *Marine Engineering*, March, 1905.

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MUNICIPAL ENGINEERING.

Water Supply.

New Form of Filter Gallery at Nancy. E. A. Gleseler. *Engineering Record*, 11th February, 1905.—About the time of Simpson's invention of sand filters, d'Aubuisson in France, 1825 to 1828, suggested to the city of Toulouse to take the raw water not from the Garonne direct, but from the gravel of the river valley, by means of a so-called "filter gallery," a gallery constructed in the gravel, parallel to the river, and supplied with suitable openings to collect the subsoil water.

The system was successful in the beginning, but in time a serious defect became apparent in all cases where the gallery not only collected the subsoil water coming from the hillside, but where it also intercepted the river water filtering horizontally through the strip of land lying between it and the river (respectively between the line of wells and the river). The impurities held in suspension by such river water would gradually clog the soil, and in course of time more and more reduce the quantitative efficiency of the gallery.

Dr. E. Imbeaux has studied this question carefully, and has arrived at a very ingenious solution, which in certain cases appears to remove entirely the above-mentioned difficulty. Generally speaking, his method consists in removing by the excavation of a trench parallel to gallery and river, that part of the soil that has become clogged, and then replacing the soil so removed by fine clean sand, which in its turn can be replaced again and again as necessity arises. It has been found that the clogging of the soil does not advance any further than from 2 to 3½ m., 6·56 to 11·48 ft., and a trench of this width is therefore all that is required.

Gravity Tunnel for the new Water-works of Cincinnati. *Engineering Record*, 4th March, 1905.—The gravity tunnel is the conduit for the conveyance of the total supply of the filtered water from the purification works, near the village of California, to Distributing Pumping Station, in the eastern part of the city. The total length of the tunnel is four and one-quarter miles.

The average depth is about 130 ft. below the ground surface and about 25 ft. below the surface of bed rock. The grade is 1 ft in 2,000 ft., descending from the clear well toward the pumping station end.

New Well and Hydraulic Pumping Plant at Peoria, Ill. *Engineering Record*, 4th February, 1905.

Water Filtration Works at Anderson, Ind *Engineering Record*, 4th February, 1905.

Revised Plans for the Purification of the Pittsburg Water Supply. *Engineering Record*, 4th February, 1905.

New Reservoir and Tower at Wallasey. *Journal Gas Lighting*, 21st February, 1905.

Masonry Dam, Swansea Water-works. *Engineering*, 3rd March, 1905.

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The Construction of Part of the Intercepting Sewers of Chicago. *Journal West. Society Engineers*, Vol. x., No. 1.

Vertical and Lateral Penetration of Sewage Bacteria into the Chalk Soil. *Engineering News*, 2nd February, 1905.

Septic Tanks and Intermittent Sand Filters at Saratoga Springs. *Engineering News*, 2nd February, 1905.

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Road Maintenance and Dust. J. George-Powell. *Contract Journal*, 15th February, 1905.

Removal of Snow from City Streets. *Engineering Record*, 21st January, 1905.

Road Paving in Germany. *Quarry*, March, 1905.

Testing of Road Materials at Columbia University, with Observations on Current Practice. A. Black. *Schl. Mines Quarterly*, Vol. xxvi., No. 2.

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Parks and Parkings. A. W. Crawford. *Proceedings Engineers' Club, Philadelphia*, January, 1905.

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Notes on Engineering Workshop Organization. R. D. T. Heap, M.Inst.C.E. *Engineering*, 3rd March, 1905.

Cost Keeping in a Machine Tool Works. J. W. Chuba. Description of works organization at the establishment of Mr. Chas. Taylor, Birmingham. *Am. Machinist*, 11th February, 1905.

L'Emploi des Primes dans les Salaires. A study of the premium system as adopted in Great Britain and the United States. *Genie Civil*, 4th March, 1905.